Planetarium Notes

ADLER PLANETARIUM

900 E. Achsah Bond Drive, Chicago 5, Ill. Wabash 1428

SCHEDULE: Mondays through Saturdays, 11 a.m. and 3 p.m.; Sundays, 2:30 and 3:30 p.m.

STAFF: *Director,* Wagner Schlesinger. *Other lecturers:* Harry S. Everett, Albert B. Shatzel.

April: STARS OF SPRING. As we learn to find and recognize the constellations, the ancient figures are projected among the stars, and the old stories and myths are told.

May: STEERING BY THE STARS.

BUHL PLANETARIUM

Federal and West Ohio Sts., Pittsburgh 12, Pa. Fairfax 4300

SCHEDULE: Mondays through Saturdays, 3 and 8:30 p.m.; Sundays and holidays, 3, 4, and 8:30 p.m.

STAFF: *Director,* Arthur L. Draper. *Other lecturers:* Nicholas E. Wagman, J. Frederick Kunze.

April: BY ROCKET TO THE MOON. An imaginary but eventful journey in a space ship of the future to view the moon's weird scenery, with a safe return guaranteed.

May: FORECASTING THE WEATHER.

FELS PLANETARIUM

20th St. at Benjamin Franklin Parkway, Philadelphia 3, Pa., Rittenhouse 3050

SCHEDULE: 3 and 8:30 p.m. daily except Mondays; also 2 p.m. on Saturdays, Sundays, and holidays. 11 a.m. Saturdays, Children's Hour (adults admitted).

STAFF: *Director,* Roy K. Marshall. *Other lecturers:* I. M. Levitt, William L. Fisher, Armand N. Spitz, Robert W. Neathery.

April: END OF THE WORLD. Various ways in which it has been said that the world might end will be discussed and demonstrated with special and spectacular equipment.

May: END OF THE WORLD.

GRIFFITH PLANETARIUM

P. O. Box 9787, Los Feliz Station, Los Angeles 27, Cal., Olympia 1191

SCHEDULE: Wednesday and Thursday at 8:30 p.m. Friday, Saturday, and Sunday at 3 and 8:30 p.m. Extra show on Sunday at 4:15 p.m.

STAFF: *Director,* Dinsmore Alter. *Other lecturers:* C. H. Cleminshaw, George W. Bunton.

April: TRAVEL TO THE PLANETS. The conditions to be found on the planets are presented. Difficulties of any possible future travel beyond the moon are explained.

May: THE 200-INCH TELESCOPE.

HAYDEN PLANETARIUM

81st St. and Central Park West, New York 24, N. Y., Endicott 2-8500

SCHEDULE: Mondays through Fridays, 2, 3:30, and 8:30 p.m.; Saturdays, 11 a.m., 2, 3, 4, 5, and 8:30 p.m.; Sundays and holidays, 2, 3, 4, 5, and 8:30 p.m.

STAFF: *Honorary Curator,* Clyde Fisher. *Chairman and Curator,* Gordon A. Atwater. *Other lecturers:* Robert R. Coles, Catharine E. Barry, Shirley I. Gale, Edward H. Preston.

April: SPRING SKIES. April skies bring a welcome message of spring. The story of these vernal constellations is one of delight to all who enjoy the out-of-doors.

May: MEN AND STARS.

Sky and TELESCOPE

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SKY PUBLISHING CORPORATION

CHARLES A. FEDERER, JR., *Editor*; HELEN S. FEDERER. *Managing Editor*

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LETTERS

Sir:

A short time ago I thought of building a "planetarium." The luminous stars which I had pasted on the ceiling of my bedroom were not very impressive, and every 20 minutes light had to be applied to them. This interrupted my lecturing and was very inconvenient. The dome of my new planetarium is of aluminum, 23 inches in diameter, and a hemisphere. The base, which can be rotated, is made mostly of wood. The base can be raised or lowered by means of a knob, to suit the height of the ceiling on which the stars are projected.

Most of the bright stars, 1st to 4th magnitude, are projected, some 400 of them for the winter sky for about the 1st of January. In order to show the summer sky, another dome will have to be made. There is a small projector, of wood and dome-shaped, for the Milky Way. I have also made a projector for the sun and for twilight, to get the audience used to the dark.

I have given several lectures with my planetarium at home, and have had invitations to give demonstrations of the planetarium at other places. I plan to make astronomy my career, and have a long way to go, as I am now 15 years of age.

EDWARD L. NEW
3647 Janssen Ave.
Chicago 13, Ill.

Sir:

On the night of February 17th, my 14th birthday, I took it upon myself to find the planet Uranus, with a pair of 8 x 35 binoculars. I soon sighted the planet, just in the place where it was indicated in the chart from the RASC **Observer's Handbook** reproduced in the February issue of

(Continued on page 150)

VOL. VII, NO. 6 — APRIL, 1948
WHOLE NUMBER 78

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COVER: The working head of the McGregor reflecting spectrometer of the McMath-Hulbert Observatory, University of Michigan. At the right is the mirror end of a 10½-inch Cassegrainian reflector which feeds sunlight into the monochromator with calcium fluoride prism (center). At left center, supported by the dark beam, is the synchronous motor drive and sector disk for interrupting incident light 1,080 times per second, before it passes into the entrance slit of the spectrometer. Visible beneath the reflector is the Leeds and Northrup Speedomax recorder, for recording the infrared solar spectrum as received by the lead-sulfide cell. McMath-Hulbert Observatory photograph. (See page 143.)

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BACK COVER: The northeastern portion of the Great Nebula in Andromeda, photographed on August 19, 1933, by John C. Duncan, Whitin Observatory, Wellesley College, with the 100-inch Hooker reflector at Mount Wilson Observatory. A Ross zero corrector was used, and the exposure was 2½ hours. Scale of this reproduction is one minute of arc to about 235 light-years. In this and the back cover of the February, 1948, issue, south is at the top. In a future issue, the central portion of M31 will complete the series.

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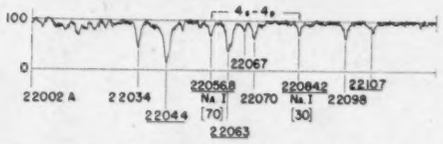
A Solar Infrared Reflecting Spectrometer

By Robert R. McMath and Orren C. Mohler

McMath-Hulbert Observatory, University of Michigan

IN ORDER fully to utilize the possibilities of the new photoconductive infrared detectors, such as the Cashman lead-sulfide cell, a reflecting optical system must be employed. Experiments during 1947 at the McMath-Hulbert Observatory have revealed so many new and important features of the solar infrared spectrum under high dispersion that we have designed and constructed a reflecting spectrometer for use with the McGregor tower telescope. A 10½-inch Cassegrainian telescope (one of the original instruments of the observatory) of 45 feet equivalent focal length, and a calcium-fluoride prism monochromator constitute the image-forming and predispersing system that precedes the main spectrograph.

The monochromator acts as a very low-powered spectrograph; the total length of the visible portion of its spectrum is about two millimeters. Its sole function is to act as a broad band-pass filter to exclude unwanted light from the main instrument. This keeps us out of difficulty with overlapping spectral orders, for the grating returns through the exit slit wave length 20,000 angstroms in the first order; 10,000 in the second order; 6667, third order; 5000, fourth order; 4000, fifth order, and so forth. By shifting the short spectrum of the monochromator along the entrance slit, we can select a band of light, say about 2,000 angstroms wide in the infrared, to be admitted to the main spectrograph, with light of all other wave lengths excluded. This procedure eliminates all trouble with overlapping spectral orders.



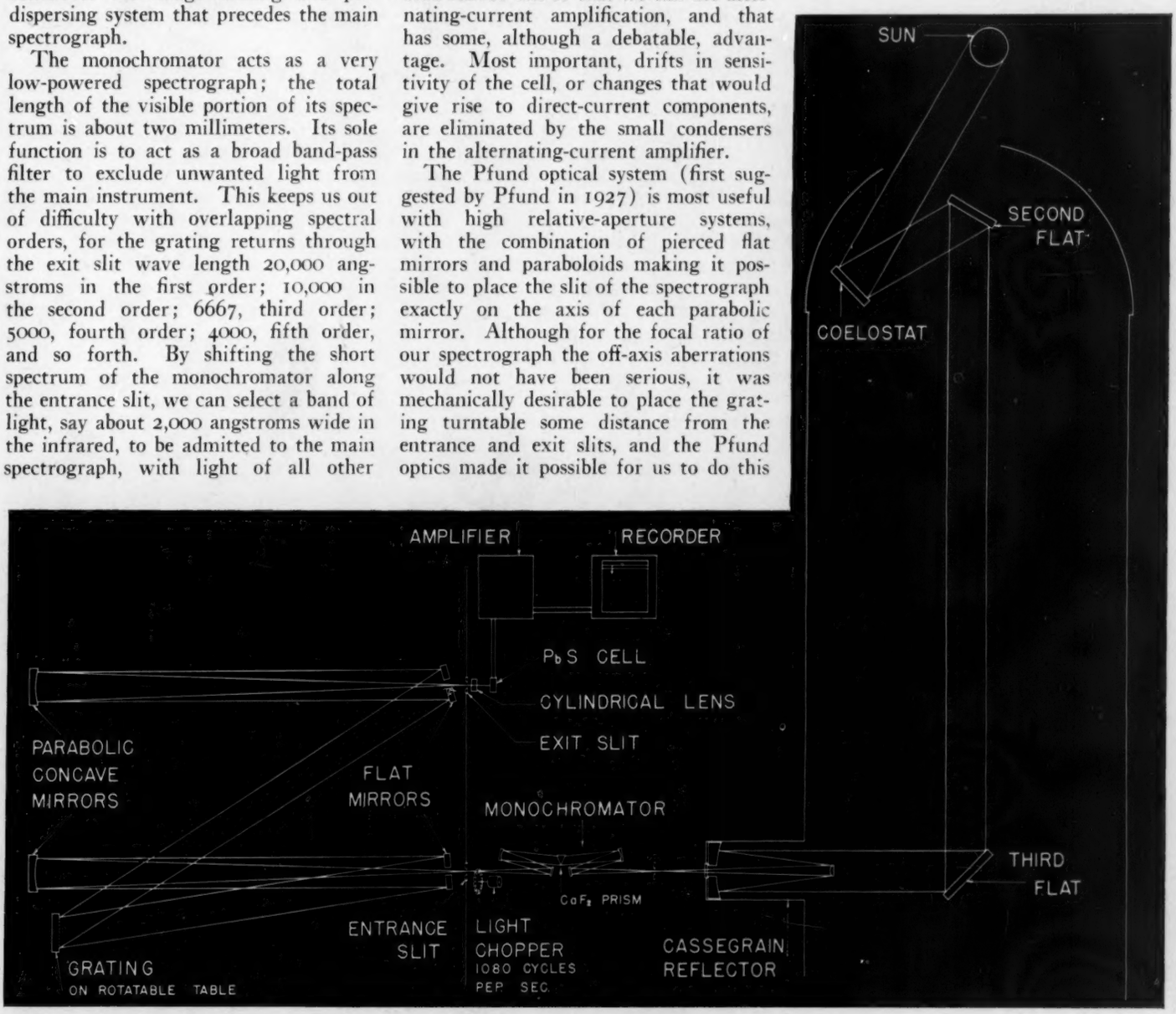
The solar infrared spectrum in the region of 22,060 angstroms, showing two sodium lines.

The light chopper, which is located before the entrance slit (see the front cover), accomplishes two things. First, it produces a pulsating signal from the lead-sulfide cell so that we can use alternating-current amplification, and that has some, although a debatable, advantage. Most important, drifts in sensitivity of the cell, or changes that would give rise to direct-current components, are eliminated by the small condensers in the alternating-current amplifier.

The Pfund optical system (first suggested by Pfund in 1927) is most useful with high relative-aperture systems, with the combination of pierced flat mirrors and paraboloids making it possible to place the slit of the spectrograph exactly on the axis of each parabolic mirror. Although for the focal ratio of our spectrograph the off-axis aberrations would not have been serious, it was mechanically desirable to place the grating turntable some distance from the entrance and exit slits, and the Pfund optics made it possible for us to do this and stay "exactly" on the optical axis.

Since our interest is primarily in highly dispersed solar spectra, we have employed an aluminized speculum metal diffraction grating as the dispersing element. The grating now in use has been kindly lent by the Mount Wilson Observatory; it is ruled with 600 lines per millimeter and is very bright in the first order infrared at about 20,000 angstroms wave length.

The chief problem encountered in the design of any spectrometer is the provision of an absolutely smooth rotation of the grating about an axis parallel to its rulings. This problem is comparable



This schematic diagram (not to scale) shows the path of sunlight from the coelostat in the 70-foot McGregor tower, through the Cassegrainian reflector and the monochromator, the Pfund optical system of the reflecting spectrometer (left portion of diagram), and through the exit slit to the lead-sulfide cell.

Mounted on this pier (from left to right) are the end of the grating drive screw; the diffraction grating on its rotatable table; the collimating mirror (dark); the image-forming mirror. The grating drive motor is below the bottom of the picture.

to that of producing an errorless drive for a large telescope. Our grating table is mounted on a specially selected precision-grinder spindle, which acts as the axis of rotation for the grating. The grating table is rotated by steel belts attached under tension to a lapped nut that is driven by a precision ground lead screw; these were obtained through the Ex-Cell-O Corporation, of Detroit. They have proved entirely satisfactory.

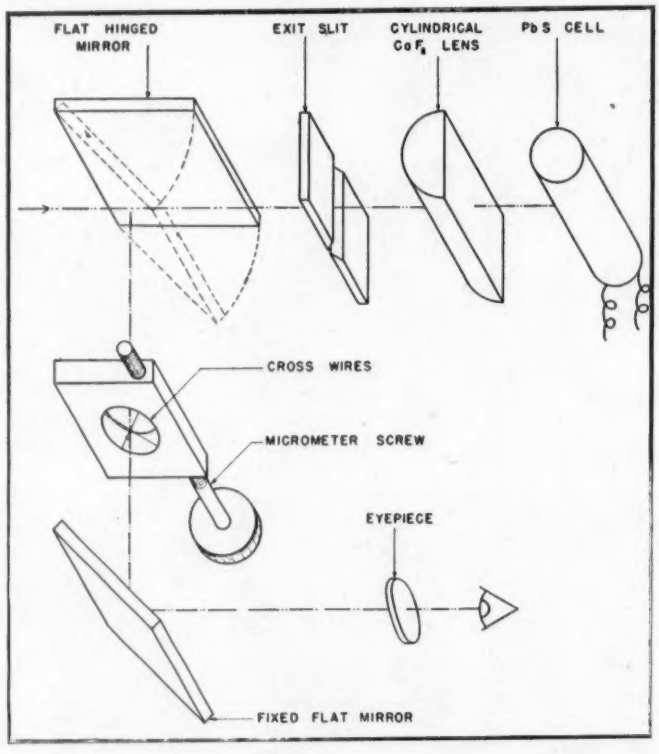
Especial care was needed to eliminate vibration set up by the grating drive motor, and to prevent transmission of minute stresses to the grating table as it rotated. The drive motor is mounted on a lead pad on the concrete floor of the McGregor spectrograph, while the grating table is carried on the isolated pier that supports the grating and collimating lens of our Littrow spectrograph. As further precaution, the drive motor is connected to the first reduction gears by a soft rubber belt, and the drive shafts connecting the several reducing units are constrained to transmit only rotation, while remaining free to move over short distances in a longitudinal direction. No errors are detectable in the drive when the spectrum is examined visually with a 20-power microscope.

On the same pier as the grating drive are mounted the 6-inch collimating and image-forming parabolic mirrors of 277 inches focal length each. The same entrance slit serves for both the new reflecting spectrometer and the refracting Littrow system, and the change may be made in a few minutes.

Visual examination of the higher-order spectra shows that the definition of the spectrum lines is very good indeed. The spectrum is finally focused on a second, exit slit which selects the narrow region of the spectrum that falls on the lead-sulfide cell to produce the photoelectric signal. As the grating is rotated at about 1½ degrees per hour, the spectrum sweeps slowly across the second slit, effecting scanning of any wave length region. Variations in intensity are recorded, after appropriate amplification of the photoconductive signal, on a Leeds and Northrup Speedomax recorder.

Two scanning speeds are provided, 0.10 and 0.05 millimeter per second. At 10,500 angstroms, these linear speeds correspond to 0.24 and 0.12 angstrom per second, since the linear dispersion at this wave length is 2.43 angstroms per millimeter. But in the region of 22,000 angstroms, the dispersion has increased to 1.87 angstroms per millimeter, with correspondingly slower rate of scan in wave length. The recording paper is driven at 0.644 millimeter per second, or 6.44 times the fastest scanning speed, hence the resulting dispersions on the recording paper are 2.65 millimeters per angstrom at 10,500, and 3.43 at 22,000. The resolving power is determined entirely by the width of 0.20 millimeter for both entrance and exit slits. At 22,000 angstroms, lines separated by 0.50 angstrom are just resolved.

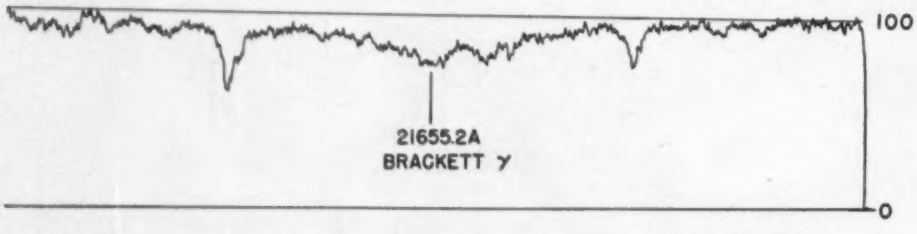
The accompanying schematic diagram shows the mirror arrangement used on the exit slit of the main spectrograph for determining wave lengths. The grating drive is reversible, and to determine the wave length of a given infrared line the observer scans back and forth across the line, eventually stopping the grating with the exact center of the infrared absorption line on the center of the exit slit. This is accomplished by watching the deflections on the Speedomax recorder as one scans back and forth. When the center of the line has been determined, the flat, hinged mirror is lowered into the position indicated by the dotted lines in the sketch. The ray of light that would normally proceed to the exit slit is then reflected downward to form an image on the indicated cross wires. The image and wires are viewed with the fixed flat mirror and eyepiece combination. The monochromator is then changed so that light of wave length 5000 angstroms or some part of the visual spectrum enters the main spectrometer.



A feature of the new reflecting spectrometer at McMath-Hulbert Observatory is the arrangement for comparing the overlapping visual wave length with the infrared line for which the wave length determination is to be made. This diagram is schematic.

The observer then sees the visual spectrum on the cross wires and can measure the positions of known absorption lines with reference to the position of the exit slit. We then have a direct

(Continued on page 158)



The third member of the Brackett series in the solar infrared spectrum.

Amateur Astronomers

THIS MONTH'S MEETINGS

Cambridge: The meeting of the Amateur Telescope Makers of Boston will be held on Thursday, April 8th, at 8 o'clock, at Harvard College Observatory. Dr. George Wald, associate professor of biology at Harvard University, will speak on "The Eye and the Camera."

Chicago: On Tuesday, April 13th, at 8 o'clock at the Chicago Academy of Sciences, the Burnham Astronomical Society will attend an illustrated talk on "Life on Other Worlds." The lecturer is John Sternig, director of science of the Glencoe Public Schools and assistant lecturer at the Dearborn Observatory.

Cincinnati: On April 2nd, the Cincinnati Astronomical Association will hear Dr. Bart J. Bok, Harvard College Observatory, lecture on "The Age of the Universe." This will be a joint meeting with the University of Cincinnati chapter of Sigma Xi, in the auditorium of the chemistry building at the university at 8 p.m. The public is invited.

Cleveland: Dr. Peter M. Millman, Dominion Observatory, Ottawa, will speak on "How and Why Shooting Stars Shine," at the meeting of the Cleveland Astronomical Society on April 23rd at 8:00 p.m., in the Warner and Swasey Observatory.

Detroit: On April 11th, Sunday, at 3:00 p.m. in room 211 of Wayne University, Professor Everett R. Phelps will be in charge of a demonstration of the Spitz planetarium which has been purchased by the Detroit Astronomical Society. All interested persons are invited to attend.

Geneva, Ill.: A lecture on "Time Determination," illustrated by sound movies, will be presented by Robert Miller, of the Elgin Watch Company Observatory, at the April 6th meeting of the Fox Valley Astronomical Society, 8:00 p.m., in the Geneva City Hall.

Indianapolis: On April 4th, at 2:15 p.m. at Cropsey Hall, the Indiana Astronomical Society will hear a lecture by Dr. Frank K. Edmondson, Indiana University, on "Work for the 'Big Eye.'"

Kalamazoo: The Kalamazoo Amateur Astronomical Association will meet on April 17th at 8:00 p.m., at the home of Dr. and Mrs. L. N. Upjohn, 1556 Long Road, when Dr. Upjohn will speak on "Contents of Space."

Minneapolis: On April 7th the Minneapolis Astronomy Club will hold its annual meeting and election of officers. On April 21st the lecture will be "The Life of a Star Gazer," by Rev. Francis Nolan. Both meetings are at 7:30 p.m. at the Public Library.

New York: "Sunspots" is the subject of the lecture by Neal J. Heines, chairman of the AAVSO solar division, at the April 7th meeting of the Amateur Astronomers Association, 8:00 p.m., at the American Museum of Natural History.

Pittsburgh: The meeting of the Amateur Astronomers Association of Pittsburgh will be held on Thursday, April 8th, instead of Friday, the 9th, in the Buhl Planetarium at 8 o'clock. The speaker is Dr. Bart J. Bok, Harvard College Observatory, concerning "The Age of the Universe."

San Diego: On Friday, April 5th, Edwin Watkins will speak on "Astronomy and Sound," with motion pictures, before the San Diego Astronomical Society, at 7:30 p.m. in Room 507, Gas and Electric Building.

Washington, D. C.: Dr. John J. Hopfield, physicist at the Johns Hopkins Applied Physics Laboratory, will speak at the monthly meeting of the National Capital Astronomers on Saturday, April 3rd, at 8 p.m. in the National Museum. His subject will be "The Solar Spectrum from V-2 Rockets."

STAMFORD AMATEUR ASTRONOMERS

Early in February a long and lively organizational session was held at the Stamford Museum in Courtland Park. Robert E. Cox, the organizer of the prewar Stamford astronomy group, who is now associated with **Sky and Telescope** and Harvard Observatory, was the main speaker of the evening. Three members of the prewar group were present. In addition to Stamford, the nearby communities of Greenwich, New Canaan, Noroton, and Norwalk were represented at the meeting.

Officers for 1948 were elected: Edwin M. Bailey, chairman; Dr. Alan F. Kirkpatrick, vice-chairman; and William L. Dutton, secretary. It was decided to call the group the Stamford Amateur Astronomers, and to hold meetings on the fourth Friday of each month at the Stamford Museum at 8:00 p.m.

WILLIAM L. DUTTON, secretary
Box 331, Noroton, Conn.

PITTSBURGH CONVENTION

A bulletin issued by the Amateur Astronomers Association of Pittsburgh on February 16th gives further plans for the regional convention of the Astronomical League scheduled for that city in May. Although the convention is to run from May 14th through 16th, it is expected that all regional business can be conducted on Saturday, May 15th. Business sessions will be held in the Buhl Planetarium, Federal and West Ohio Sts., Pittsburgh, Pa., which many will remember as the site of the second national convention of amateur astronomers back in 1940.

The convention will open with a "get-acquainted meeting" on Friday, May 14th, at 8:15 p.m. at the planetarium. The first business session is to be held at 9:30 a.m., Saturday, May 15th, for the purpose of establishing the region. The second session will be at 1:00 p.m. for the election and installation of regional officers, and determining future regional programs and policies. The closing session, at 8:00 p.m., will be addressed by Dr. N. E. Wagman, director of Allegheny Observatory. Following this, guests will visit the Allegheny Observatory, and if weather is clear, use the 30-inch Thaw refractor. Sunday will be devoted to entertaining delegates, with a demonstration in the planetarium and a visit to a prominent optical manufacturing plant included in the plans.

As already announced in **Sky and Telescope** in February, this region extends from Michigan (except the upper peninsula) across to New Jersey (except the upper corner near New York City) and including Virginia, Kentucky, and Indiana. Tentatively known as the Middle Atlantic region, the convention may consider East Central or Middle Eastern region more appropriate. Delegates are asked to give this some thought.

All amateur astronomers are invited to attend this convention, although voting on league business will be limited to members of member organizations. Further information may be had from the undersigned.

CHARLES H. LEROY
R. D. 2, Pittsburgh 15, Pa.

Indexes and Bound Volumes

All volumes of Sky and Telescope are fully indexed, and the indexes are available at 35 cents each postpaid. Send 35 cents in stamps or coin or include with your renewal check or money order. Bound volumes, at $6.50 each postpaid, are also now ready for Volumes II, IV, V, and VI.

SKY PUBLISHING CORPORATION

SACRAMENTO COLLEGE OBSERVATORY REOPENED

On the evening of February 11th, the Sacramento College Observatory was reopened, after five years of wartime inactivity. Approximately 100 persons attended the opening, which was sponsored locally by the Sacramento Valley Astronomical Society. The evening's lecture, one of a series endowed by the Morrison Foundation of the Astronomical Society of the Pacific, was on "The Dark Clouds of Interstellar Space," given by Dr. Harold F. Weaver, Lick Observatory. Observing followed the lecture.

The observatory is equipped with a 12½-inch reflecting telescope, equatorially mounted, which was constructed by local amateur astronomers in 1938-39 and presented to the college. The instrument is for the regular use of the college astronomy classes, as well as for demonstration to science classes throughout the city school system. Teachers and others desiring to bring science classes to the observatory should communicate with Leon Salanave, instructor in astronomy, who is in charge.

ELIZABETH CHAMP
Secretary-treasurer
Sacramento Valley A. S.

NEWS FROM IRELAND

The Irish Astronomical Society now has three centers, at Armagh, Belfast, and Dublin, and a total membership of over 300. Headquarters of the society are at the Armagh Observatory, and its director, Eric M. Lindsay, is president. Professor H. A. Bruck, of Dunsink, is vice-president, and J. H. McElderry, of Belfast, is secretary-treasurer.

Dr. E. Opik, formerly of Estonia, and particularly well known for his research on meteors, has accepted the post of research associate at Armagh Observatory.

NEWS NOTES

By Dorrit Hoffleit

EARTH'S SHAPE AND ECLIPSES

The annular eclipse of May 8th-9th is getting almost as much attention as total eclipses of the sun usually do. It is going to help measure the size and shape of the earth with great accuracy. The National Geographic Society, the Army's Map Service, Engineers and Signal Corps, the Navy, Air Force, National Bureau of Standards, Coast and Geodetic Survey, and the State Department are co-operating in sending expeditions to seven observing points in Burma, Siam, China, Japan, Korea, and the Aleutians.

By timing exactly the instants when the moon first contacts the sun, when the ring of light around the moon first appears and first disappears, and when the eclipse is just over, as seen from the various stations, the scientists will be able to compute how far apart their observing positions are with errors not exceeding 150 feet.

Expedition leaders include Edward A. Halbach, Milwaukee Astronomical Society; Rev. Francis J. Heyden, of Georgetown Observatory; Dr. Charles H. Smiley, Ladd Observatory; Dr. George Van Biesbroeck, of Yerkes Observatory, who will be stationed respectively in Burma, China, Siam, and Korea. American observers are scheduled to reach their observation posts about April 1st.

Two dates are given for this eclipse because its path crosses the international date line.

VARIOUS TELESCOPES

Recently there have been announced plans for new telescopes at various institutions and transfers of older equipment to places where it can be more effective. Thus Harvard has sent its 11-inch Draper telescope to China (*Sky and Telescope*, November, 1947), and the University of Cincinnati is lending a 10-inch Cooke triplet camera to Indiana University, so that astronomers at Indiana may help keep track of some of the minor planets as part of a nationwide program of research in which 18 major astronomical observatories are co-operating. Adjunct to the new telescope at Indiana will be a new plate-measuring machine; also, the University of Minnesota's astronomy department has lent a blink comparator for the purpose of detecting asteroids on the Cooke plates.

The University of Michigan is constructing an observatory which will have as its principal instrument a 24-inch Schmidt telescope. The new observatory will be located in Stinchfield Woods, near Ann Arbor and near the university's new FM radio tower on Peach Mountain. President Alexander G. Ruthven expects construction to be completed within the year. The new instrument will be important in aiding expansion of the teaching facilities of Michigan's astronomy department, and will also be used for research on the structure of galaxies and the Milky Way, and possibly on solar system bodies.

One hundred thousand dollars of the $260,000 total cost of the new observatory were granted by the McGregor fund of Detroit. A two-story building will have a dome for the Schmidt telescope 28 feet in diameter. Warner and Swasey will build the instrument.

From Ladd Observatory, Brown University, we hear of the progress of solicitations for funds for a 20-inch reflector for the University of Krakow, Poland. This will be the largest telescope in that country, and it is to be used for photoelectric measurements of eclipsing binaries. The optical parts are being made by Stanley Brower of the Laboratory Optical Company. Dr. Stefan Piotrowski, of Krakow Observatory, has recently returned home after conducting research at Harvard College Observatory on an Agassiz fellowship provided through the Kosciuszko Foundation.

TEN THOUSAND PLATES BY ONE OBSERVER

On February 12th Sproul Observatory, Swarthmore College, lost its most faithful night observer. Roy W. Delaplaine, by profession a physical education leader in Philadelphia, devoted much time and effort to the heavens. In 1929 he took his first parallax plate with the 24-inch refractor. His last night at the telescope was September 17, 1947, and in the interval he took nearly 10,000 such photographs, which is more than one third of the total since the telescope was put into operation in 1912. Mr. Delaplaine was 62 years old when he died.

NAVIGATION INNOVATIONS

Perhaps in the future on overcast days the navigator will use a radio sextant to determine the precise position of the sun from the arrival of solar radio noise. At present, the National Bureau of Standards is planning two radar mirrors 25 feet in diameter for its Radio Propagation Laboratory at Sterling, Va. The mirrors will automatically follow the sun and measure its noise, which at ultra-high frequencies appears as a steady hiss and undulation. In radio reception, other recognized classes of noise originate in the earth's atmosphere as ordinary static, and in the Milky Way as cosmic noise.

Meanwhile, Dr. Henry L. Yeagley, Pennsylvania State College physicist, has been investigating how homing pigeons find their way home. He discovered that some pigeons don't! Taken west of a midway point, the pigeons flew to a place in Nebraska instead of back to their home. Science Service reports that Dr. Yeagley noted that the intensity of the earth's magnetism and the rate of rotation of the earth are the same at the two points, and he suggests these may be the factors by which birds navigate. He urges that biologists and psychologists study his results and try to find whether or not human nerves react to the magnetic field of the earth when cutting the lines of force at modern high airplane speeds.

At the December meeting of the American Association for the Advancement of Science, O. C. Collins, of the University of Nebraska, described a new method for the determination of position from the stars. The new method, using standard equipment such as sextant or bubble octant, requires only five minutes to predict where the craft will be in 10 minutes, rather than longer time to tell where it was 10 minutes previous to the observations. The method is based on observing two bright stars when they are exactly the same height above the horizon. With data for 65 pairs of stars already computed, military and commercial airline navigators have tested the method satisfactorily for about 18 months, but a complete table would include 1,485 pairs which may be formed from the standard 55 navigational stars. The method is expected to be particularly good near the poles of the earth, and plans are under way for sending a testing expedition to Greenland.

NAVY RESEARCH FUNDS

The Office of Naval Research now has available limited funds for the support of pure research in astronomy and astrophysics. At the request of the ONR, a committee from the American Astronomical Society has been appointed by the National Research Council to advise on the disbursement of these funds.

There will be established post-doctoral and pre-doctoral research projects, providing salaries for individuals and expenses for research equipment, and giving preference particularly to projects that involve close collaboration between the individual and the institution where the major part of the proposed research is to be carried out. There will also be joint projects involving two institutions, preferably a larger and a smaller observatory or astronomy department. In some cases projects originating within an institution will be supported, particularly where there are no funds available for experimentation and development in new fields.

SPRING SKIES

By Catharine E. Barry, *Hayden Planetarium*

Some man of yore
A nomenclature thought of and devised,
And forms sufficient found
* * *
So thought he good to make the stellar groups,
That each by other lying orderly,
They might display their forms. And thus the stars
At once took names and rise familiar now. —Aratus

AT TIMES the weather can deceive us in regard to the season of the year. It may feel like January in June, or June in January. Better then, that we be guided by the constellations to announce the change in seasons. Leo, the Lion, will always herald the spring for us. The unique Scorpion, with the red supergiant Antares as his heart, scintillates directly in the south when the stars first appear in the evening skies of early summer. The Great Square of Pegasus gives ample warning of the arrival of autumn, and Orion, the mighty hunter, is monarch of all he surveys in the vivid winter sky.

Of course, on any clear night, if you observe from twilight to dawn, you may have a review of the preceding season's stars and a preview of next season's. So actually in much less than a year of time you can review all of the naked-eye stars observable in your latitude. And, although the winter months give birth to the brightest stars, the mildness of spring is an inducement to get out star charts, and perhaps to use binoculars or telescopes to scan the heavens to greater advantage.

Among the spring star groups are many constellations which are not so well known as the brighter, more popular ones. We shall here call attention to these lesser lights, for they can, with practice, be recognized nearly as easily as the Big and Little Dipper can, granted a clear sky.

It is well to begin, however, with the Big Dipper, which is usually listed as a spring star group as it is advantageously placed for observation in the evening at this time of year. At about 9 o'clock local time in the middle of April, Merak and Dubhe, the Pointer stars on the outer edge of the Dipper bowl, are almost directly above Polaris and, of course, pointing to it. The Dipper handle curves off to the east, leading to the 1st-magnitude orange star, Arcturus.

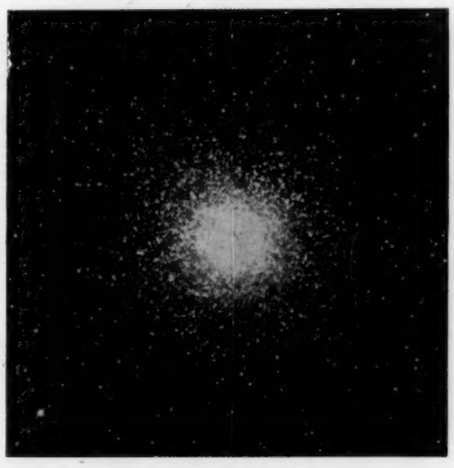
Beneath the curve of the Dipper's handle is the constellation Canes Venatici, the Hunting Dogs. It takes a good imagination to visualize the two greyhounds held in leash by Bootes as they pursue Ursa Major, the Great Bear, around the pole. Alpha in Canes is Cor Caroli, which means "heart of Charles," a fine double star for amateur observers. It is easily found by imagining a line from Dubhe, the northern Pointer, extending diagonally across the bowl through Phecda and about twice that distance beyond.

Canes is a modern star group established by Hevelius. The more northern dog is Asterion, marked by very faint stars. Chara, the other dog, contains Cor Caroli in its collar, and a 4th-magnitude star marked Beta, and also called Chara. Cor Caroli crosses the meridian in May evenings, and forms with Spica, Arcturus, and Denebola a quadrilateral known as the Diamond of Virgo.

In Canes is located M51, a magnificent spiral galaxy known as the Whirlpool nebula. Unfortunately, it cannot be seen in any detail without a powerful telescope, but it is worthwhile to study modern photographs of it.

A line from the last star in the Dipper handle through Cor Caroli and extended that distance again ends in a most beautiful group of stars — a real star cluster — which greets the discerning eye as a cascade of loveliness against the dark vault of the heavens. This is Coma Berenices, Berenice's Hair. Eratosthenes was the first to mention this faint group and he called it "Ariadne's Hair." The Egyptians called it "the many stars." According to *Star Lore of All Ages,* by William Tyler Olcott, "other titles for it are 'Berenice's Periwig,' and 'Rosa,' and the figure has been thought to represent the tuft of hair in the Lion's tail, and the sheaf of wheat held by the Virgin."

The Coma star cluster is one of the nearest galactic clusters, about 263 light-years away. There are also several fine globular clusters in this region, such as M3 and M53, and Coma is noted, along with Canes Venatici and Virgo, as one of the best regions of the sky in which to observe exterior galaxies. This is because it contains the north galactic pole, 90 degrees from the equator of the Milky Way. It is this part of the sky which is least obscured by galactic dust, so that we may look beyond the confines of the Milky Way galaxy to see those galaxies which lie beyond.



The globular cluster M3, in Coma Berenices, in which nearly 200 cluster-type Cepheid variables have been studied.

Some of the constellations which dominate the skies on spring evenings.

This is truly a season of rich reward in the sky. At about 9 p.m. in mid-April you will find Rigel, intrinsically one of the brightest of stars, and located in the left foot of Orion, about to set in the southwest. Also visible at this time are Betelgeuse, Aldebaran, Capella, Sirius, Castor, Pollux, Procyon, Regulus, Arcturus, and just about to rise in the east are Vega and Spica — all most noteworthy stars. When Coma Berenices reaches the zenith in mid-northern latitudes, the Milky Way extends almost all the way around the horizon.

When you follow the bend in the handle of the Dipper and extend the line on to Arcturus and then about that same distance beyond, you come to Spica, the brightest star in Virgo. Virgo is one of the constellations of the zodiac, located between Leo and Libra, with some of its stars rather bright, and others faint.

Spica is a spectroscopic binary noted for its pure whiteness; its period is four days. The name means "ear of wheat," referring to that which Virgo is imagined holding in her left hand. Spica is of apparent magnitude 1.2, about 120 light-years distant. It would require 440 of our suns at that distance to look as bright as Spica does to the stargazer on earth. In ancient times this star was known as "the star of prosperity." The

Egyptians oriented some of their temples to Spica.

To the west of Virgo along the ecliptic are Leo and Cancer, in which now are Mars and Saturn, both near Regulus and the Sickle. As the time of Mars' nearest approach to the earth passes, the ruddy planet fades in brightness rapidly, and Mars and Saturn will be equally bright by the end of April. But both considerably outshine Regulus and Gamma Leonis, brightest stars in the Sickle.

These stars may be used, however, to act as pointers southward to Alphard, the most conspicuous star in Hydra, the Water Snake. This star has been called "the lonely one," because of its isolated position in a part of the sky where only faint stars are seen. The head of the snake is to the northwest of Alphard, just below Praesepe, a galactic cluster which is the most conspicuous feature of Cancer, the Crab. Hydra extends eastward for more than 90 degrees, and is one of the longest constellations in the sky.

On the back of Hydra are two other figures, Corvus, the Crow, and Crater, the Cup. Corvus is often called "the spanker," after a type of sail which it resembles. Its top (northern) stars point directly to Spica. Crater is about 15 degrees to the west of Corvus and due south of Denebola. Six faint stars make the cup and it is easily seen once you pick out the semicircular formation.

When the central part of the Dipper is on the meridian on mid-spring evenings, one may find spaced to the south of it in succession Canes Venatici, Coma, the Lion's tail, the bright western portion of Virgo, Corvus, and the tail of Hydra. Far to the south, invisible to northern observers, the Southern Cross is also on the meridian at this time, and those living in southern Florida and Texas may see Crux above the south point of the horizon.

As the stars of spring are many, we have only begun to discuss them. With a good star chart as your guide and some optical aid, if possible, there are wondrous surprises in store for you. For there is no lamp as cheering as those let down by obliging gods at night to illuminate this tired but restless world.

A well-known spiral galaxy, Messier 51, the Whirlpool nebula, in Canes Venatici. Its apparent magnitude is 11.1. The central portion is NGC 5194, and the condensation below it is NGC 5195. This picture is a three-hour exposure with the 100-inch telescope at Mount Wilson Observatory.

MOON TELEVISED

Weekly television broadcasts on science have been originating from the studios of WPTZ, Philadelphia, planned and presented by Dr. Roy K. Marshall, director of the Fels Planetarium of the Franklin Institute. The series, entitled "The Nature of Things," is devoted to elementary demonstrations and experiments in various fields of science. On February 24th, when the elaborate remote pickup equipment of WPTZ was moved to the rooftop observatory of the Franklin Institute for a special 30-minute telecast on telescopes and telescope making, clouds prevented observing the moon. On the 26th, however, the image of the 17-day-old moon was put on the air, from a remote pickup at the Philco transmitter a few miles north of the studio.

At the transmitter Dr. I. M. Levitt and Edwin F. Bailey, other members of the Fels Planetarium staff, used a 7-inch reflector, f/10, to deliver the image to the television camera. Thus, thousands of televiewers in Philadelphia and New York were simultaneously able to observe the moon telescopically. Future programs of this nature are already being planned. The amount of light available from the moon is about 20 times the minimum required, so that enlarged images of portions of its surface can also be telecast.

This is not the first time astronomical television has been accomplished. In 1940, at the time of the annular eclipse of the sun on April 7th, the attendant partial eclipse was televised by RCA-NBC studios from the RCA building in New York. A 4-inch rich-field reflector constructed by a member of the optical division, Amateur Astronomers Association, projected an enlarged image to the television camera, with successful reception in the New York area. (See The SKY, May, 1940, page 15.)

AMERICAN ASTRONOMERS REPORT

Here are highlights of some papers presented at the 78th meeting of the American Astronomical Society at McMillin Observatory in December. Complete abstracts will appear in the Astronomical Journal.

Variables in Globulars

DR. HELEN SAWYER HOGG, of David Dunlap Observatory, has now added the bright cluster Messier 9 to her list of globulars in which variables have been studied. This cluster is in Ophiuchus, a constellation which contains 20 globulars. Sagittarius has 17, and there are 99 known objects of this type in the entire sky.

A blink survey of 30 pairs of plates by Dr. Hogg added 13 new variables in M9 to one such star previously known. Measures on 78 plates from David Dunlap and the Steward Observatory in Arizona indicate that the new variables are all of the RR Lyrae type, with periods ranging from one quarter to three fifths of a day. No long-period Cepheids were found.

The number of globular clusters examined for variables is increasing very slowly now, as more difficult objects are being studied, but the number of variables found is still increasing substantially. In 1930, 45 clusters had been examined, and 886 variables found; by 1939, 60 clusters yielded 1,116 variables; by 1947, 1,307 variables had been discovered in 62 clusters.

A Peculiar Blue Star

IN ONE of the densest portions of the obscuring dark clouds in Taurus is a faintly luminous nebula discovered by Barnard in 1907 and called B 10. The nebula has a radius of five minutes of arc and is illuminated by a 15th-magnitude star. Both the nebula and the star are very blue. The star is, however, intrinsically of the 10th magnitude absolute if the distance of nebula and star is assumed to be about 100 parsecs, whereas the nebula shines as it would if illuminated by a star about seven magnitudes brighter.

Discussing this peculiar case, Dr. Otto Struve, of Yerkes and McDonald Observatories, who collaborated with Dr. P. Swings in the investigation, suggests that there may exist some as yet unknown process whereby strong ultraviolet stellar radiation is converted by the particles composing a nebula into more-or-less continuous radiation of longer, visible wave lengths. The blue star has a spectrum with very strong hydrogen emission lines, a strong Balmer continuum, and devoid of absorption lines. There are also strong emission lines of ionized calcium, and weaker helium lines. The star is a kind of blue "white dwarf" with strong emission lines — previously unknown among single stars but having some resemblance to the underluminous emission-line companions of certain double star systems.

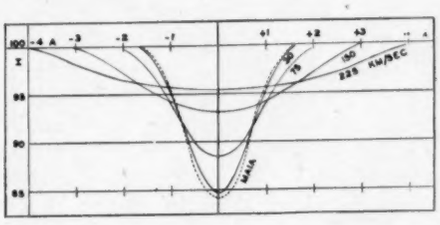
Dr. Struve believes this star, associated as it is with the Taurus nebulosity, may possibly be a star in the process of formation. Its luminosity is insufficient to drive away small particles by radiation pressure, and the impact of nebulous matter may be responsible for the origin of its strong emission lines. Already several emission-line stars have been found by Joy in the Taurus region.

Stellar Rotations

BY MEANS of the broadening of the magnesium lines in their spectra, the rotational velocities of all the class *B* stars within one degree of Alcyone, brightest star in the Pleiades open cluster, have been measured by Drs. Elsa van Dien and J. A. Pearce, of the Dominion Astrophysical Observatory. The mean rotational velocity for the 15 stars involved was found to be 164 kilometers per second.

The 4th-magnitude Maia, of spectral class *B*7, is the only Pleiad of this class having a sharp-line spectrum, its equatorial rotation being estimated by Smith and Struve as 25 kilometers per second. This star was therefore selected as the standard for Dr. van Dien's measurements, and it was assumed that the profile of the Mg II line in its spectrum at wave length 4481 is merely instrumental contour. A rotational velocity of 30 kilometers per second hardly changes the instrumental profile, so that rotations of less than this amount cannot be determined by this method. The half-widths of the broadened lines are a good measure of the rotational velocities, which were deduced from the measured mean contours in three to five spectra for each star.

Alcyone itself, estimated to rotate at 250 kilometers per second, was not measured as only high-dispersion plates were available. Pleione was rejected, as its apparent velocity of 30 kilometers per second refers to the shell spectrum of this star. Some other stars were reclassified, a few from *B*9 to class *A*, leaving 15 stars for which results were obtained. The measured rotational velocities are subject to an uncertainty of 15 per cent. For stars of class *A* the line at 4481 cannot be used due to its wings and to blends with neighboring lines.



Predicted contours in the spectra of rapidly rotating stars for the magnesium 4481 line. Diagram from the Dominion Astrophysical Laboratory.

Maximum observed velocities are about 250 kilometers per second for two stars, and three stars were found to be rotating at about 220 kilometers per second. The results were in fair agreement with velocities previously estimated by Smith and Struve.

In another paper, by Arne Slettebak, of Yerkes Observatory, the problem of the equatorial instability of the bright-line *Be* stars was discussed. Rotationally broadened line contours have been computed by a graphical method and compared with the corresponding observed contours in *Be* stars. The Roche model at the instability point where centrifugal force and gravitational attraction just balance was used, on the assumption that the main-sequence *Be* stars are rotating so rapidly that equatorial instability has occurred, as suggested by Struve. For a *B*3 main-sequence star this model gives an equatorial rotation of 560 kilometers per second. For the helium line at 4026 angstroms, agreement between the predicted and observed contour of the star Beta Monocerotis A, of class *B*3nne, supports the rotational instability hypothesis.

An Electronic Computer

EDVAC is a large-scale automatically sequenced binary Electronic Discrete VAriable Computer, developed under the Office of the Chief of Ordnance, U. S. Army. It was described by L. P. Tabor, of the Moore School of Electrical Engineering, University of Pennsylvania, where three computers are being constructed, one of them to be retained at the Moore School where it will be available for the solution of research problems in astronomy and other sciences.

The EDVAC will use a four-address code and will be capable of executing the following orders: *A*, add algebraically; *S*, subtract algebraically; *M*, multiply algebraically and round off to 43 binary digits; *m*, multiply algebraically and retain 86 binary digits; *D*,

divide algebraically and round off to 43 binary digits; *d*, divide algebraically and store both quotient and remainder in memory; *C*, compare (by subtraction) two numbers, and proceed on one of two routines, depending upon the sign of the result of the comparison; *E*, extract, a comprehensive order permitting shifting and interchange of digits between two numbers or orders; *W*, wire order, a comprehensive order permitting transport of input and output wires, and reading in or reading out of data; *H*, halt.

The high-speed memory will be of the mercury acoustic type, and will have a capacity of 1,024 words. Numerical data is fed into the input system as decimal numbers, and converted to binary numbers by the EDVAC. Similarly, conversion from binary to binary coded decimal numbers is done within the EDVAC in the case of output data, and decimal numbers are printed by the output system.

The average time required for an addition or subtraction operation is less than one millisecond; that for a multiplication or division operation is less than three milliseconds.

Reversing Layer Temperature

LABORATORY investigations by Michelson showed that the half-width of sharp spectral lines is due to the thermal random motions of the individual emitting or absorbing atoms. This same principle may be applied to the Fraunhofer lines in the sun's spectrum to determine the kinetic temperature of the reversing layer in the sun's atmosphere. Measurements of the widths of numerous faint lines at half their central intensity for the elements vanadium, chromium, iron, and nickel, in the Utrecht solar atlas, when corrected for the broadening effects of the spectrograph, yield a temperature of 16,000° centigrade.

The layers which produce the solar absorption lines may actually be at this high temperature, or the line width may be caused by a temperature broadening corresponding to 5,700° plus a widening due to turbulence of two kilometers per second between convective cells in the sun's atmosphere. The temperature of 5,700° is the solar surface temperature based on ordinary radiation laws. But if the widening is due solely to turbulence, then the half-widths of lines for elements of different atomic weights should all be the same. If it is solely a temperature broadening, then the lighter elements will have wider lines due to the greater thermal velocities of the lighter atoms.

A test of the two hypotheses is thus possible, and has been carried on by A. Keith Pierce and Dr. Leo Goldberg, of the University of Michigan Observatory. Measures of the half-widths of lines due to carbon, nitrogen, oxygen, sodium, aluminum, and silicon, together with the lines in the iron group, show an increasing width for the lighter elements. We may conclude from these results that widening due to turbulence is negligible, and the principal cause is temperature broadening.

Beta Cephei Variables

SUDDEN OUTBURSTS of light in two short-period variables have been detected photoelectrically by Olin J. Eggen, of Washburn Observatory. The stars are Beta Cephei itself and HD 199140, which have nearly identical periods of 0.19 days. These stars have long been puzzling because their spectral lines exhibit periodic displacements similar to those in double stars. Previous observations of their changes in brightness gave poor light curves because the total range in light was near the limit of accuracy of the observations themselves.

The photomultiplier photometer used by Mr. Eggen has given good light curves similar to those of cluster-type Cepheids. But in both stars he recorded an aperiodic outburst of light, amounting to more than the total amplitude of the light variation in the case of HD 199140 (light range 0.28 magnitude; outburst greater than one magnitude). This phenomenon lasted only 10 to 20 seconds and occurred at the same point in the light curve of each star.

Infrared from the Galactic Center

IN 1946, Drs. Joel Stebbins and A. E. Whitford, of Washburn Observatory, showed that a photoelectric cell sensitive to the near infrared (10,000 angstroms, or one micron) could penetrate the dust clouds of the Sagittarius region well enough to detect the radiation from the central regions of the Milky Way galaxy and to show the rough outline of the galactic "nucleus." Now, the lead-sulfide cell developed by R. J. Cashman, of Northwestern University, has been used at Lick Observatory at the focus of a 15-inch searchlight mirror (to provide a fast optical system) to detect this same radiation at twice the wave length, or two microns.

The results, reported by Dr. Whitford, show that the central region of the Milky Way is indeed brighter than the brightest star clouds visible to the eye. Comparison with the previous near-infrared observations confirms that the radiation is of a deeply reddened quality which could only result from passage through dense dust clouds. Relatively little detail could be made out because of the short focal length of the searchlight mirror; if a sharp central nucleus like that of certain other galaxies exists in our own, it would have been blended into the background and missed.

RADAR RADIANTS

The *Handbook* of the British Astronomical Association, in its "Meteor Diary," reflects current trends. In addition to the usual descriptions of anticipated visual showers, a second table is added, "Daylight and Moonlight Streams," for those who are equipped to observe meteors by radar. The radiants listed are observable at latitude 52° north.

The radar list contains six showers, including the Lyrids on April 20th to 22nd. Notable as occurring from May 6th to July 30th are the daylight Piscids, discovered by Lovell and his co-workers with radar. The *Handbook* notes that the Eta Aquarids are being retained in the diary as a separate stream, but there are grounds for thinking that they are merely the beginning of the great daylight stream and are not connected with Halley's comet.

TICKER-TAPE SEISMOGRAPH

At Harvard University a graduate student in geology, Roland K. Blumberg, has designed a new seismograph which records all three components of earthquake vibrations and transmits its record to ticker tape in the seismologist's office. Thus the photographic process required for most seismograph records has been eliminated and the presence of an earthquake can be detected as soon as it occurs. The new instrument is expected to be of great value to meteorologists in detecting the motions of storm centers at large distances from the observer.

IAU EXHIBIT

An exhibit relating to new developments in instruments used for astronomical research will be held at the meeting of the International Astronomical Union, Zurich, August 11-18, 1948. Astronomers everywhere are invited to contribute exhibits of instruments, auxiliary apparatus, and diagrams. These should be sent not later than May 1st to Eidgenössische Sternwarte, Instrumental Exhibition, Schmelzbergstrasse 25, Zurich, Switzerland. Parcels and cases should be marked: "Für Ausstellung, anlässlich des astronomischen Kongresses."

LETTERS

(Continued from page 142)

Sky and Telescope. The 6-degree field of view appeared like a miniature of the constellation of Corvus, with Uranus in place of Gamma Corvi. The other three stars were Zeta Tauri, 114 and 112 Tauri, with Uranus fainter than any of them.

I also had the pleasure of seeing Mercury during the first week of February, although houses partly block my view of the western sky.

HYRON SPINRAD
3510 Divisadero St.
San Francisco 23, Calif.

The new museum was inaugurated by a great shower of meteors.

American Meteorite Museum

Opposite Meteor Crater On Highway 66

By H. H. Nininger, *Director, American Meteorite Museum*

ON OCTOBER 9, 1946, in the late afternoon, as our planet was edging into the stream of small meteoroids which later that evening were to stage such a gorgeous meteoric display for observers in this hemisphere, a huge freight van, laden with a 17,000-pound cargo of meteorites, backed up to the door of a brown stone building on U. S. Highway 66 in Arizona. Three hours later the last of the 189 cases, bags and boxes was deposited under roof, 4,000 pounds of heavy irons were dropped to the ground from the rear end of the truck, and the writer and his small group of helpers joined the womenfolk who had for some time been exclaiming over the thickening celestial display. Weary of body, they were thrilled in spirit by the shower of meteors associated with Comet Giacobini-Zinner, as it surpassed anything they had previously seen.

The next eight days were crowded with the laborious tasks of unpacking, placing, and labeling, but on October 18th the doors of the new institution opened and within an hour the educational program of the first meteorite museum was under way. Now that we are well into our second year, we find that in the first 12 months there were more than 33,000 paid admissions to the American Meteorite Museum. Visitors came from every state in the Union and from 43 foreign countries. There were classes from 15 colleges and high schools. More than 5,000 books and pamphlets were distributed.

In this museum every visitor receives personal guidance among the exhibits and more or less of group instruction according to individual tastes. Three- to five-minute lectures are given throughout the day, the total verbal instruction amounting to more than 2,000 hours for the first year. Besides this, a number of extension lectures were given before schools and clubs in several Arizona towns.

The regular museum staff consists of the writer and his wife, who are assisted by George D. Thompson, guide-lecturer, and Mrs. Ruth M. Thompson, receptionist. Additional help has been employed from time to time.

The future program is planned to include as much research as possible. During the first year there were three short field expeditions and numerous trips to and around the famous Barringer meteorite crater. An extensive field survey is now being undertaken to ascertain insofar as possible the distribution of such meteorites as still remain in the soil of the region. To supplement this knowledge, we seek information as to the amount of meteoritic material from this fall that is at present in the various collections of the world and in other situations.

In nearly all instances, the material from this fall bears the label, "Canyon Diablo, Arizona." We are therefore asking those in charge of collections of meteorites, and others who have knowledge of the whereabouts of specimens from this location, to report to the American Meteorite Museum (P.O. Box 1171, Winslow, Ariz.) the location of each such collection; the total number of Canyon Diablo specimens in the collection; the total weight of all such specimens, and the individual weights of all pieces of five pounds or more.

In connection with this investigation, it will help us to know the whereabouts and approximate size of any nickel-iron meteorite the source of which is not certainly known. We may be able to establish its identity. The results of this study of Meteor Crater will be published when the work is complete.

Just as did its predecessor, the American Meteorite Laboratory (in Denver, Colo.), the new museum maintains a free testing and identification service on suspected meteorite samples, and has reported on several hundred samples during the year. The cutting and polishing laboratory will be set up when electric power becomes available in the near future.

Another activity being resumed from prewar days is work on fireballs. With the constant stream of visitors from both east and west along one of the nation's chief thoroughfares, we are uniquely situated for gathering prompt reports on spectacular meteoric phenomena from widely distant points. By posting a bulletin conspicuously we may expect reports within a few hours. This facility was accidentally discovered on one occasion by the casual mention of a large fireball which had been seen from the

The American Meteorite Museum contains:

The largest mass ever found in connection with the world's largest meteorite crater.

A nickel-iron meteorite which was found wrapped in "mummy cloth," buried in an ancient ruin.

The largest known shower of stony meteorites.

Four stones from the shower which almost broke up a burial service near Denver in 1924.

A fragment from a stone which fell August 2, 1946, in Texas.

Two thousand stones from a shower which fell 55 miles east of the great Arizona crater in 1912.

An implement fashioned from a meteorite by a Mexican blacksmith, and a dozen hammer stones from central Mexico.

A meteorite which was doing service as a "dead man" under a fence on a Texas ranch.

The only known copper meteorite in the world.

An Indian ax fashioned from a nickel-iron meteorite, found in a ruin in New Mexico.

A meteorite which fell into a house.

One of the exhibit rooms of the American Meteorite Museum.

museum the evening before. It turned out that two parties were present who had witnessed the same fireball from two points 300 miles apart, one party while traveling east, and the other while going west.

We therefore urge observers or institutions where reports of such phenomena are received to wire us immediately the time, location of observer, apparent course, and direction of end point, and we shall post the bulletin immediately and communicate with the informant as reports are obtained.

We invite groups who pass through the southwest this summer to plan a visit to the museum. A special demonstration can often be arranged for the occasion, and with advanced students specific problems in meteoritics can be discussed in subsequent lectures by arrangement. Some of the subjects which the museum is ready to present and to illustrate with exhibits of material are:

1. *Classification.* The major portion of the 80 varieties of meteorites listed in the literature are represented in our collection.

2. *Surface features* and problems of air resistance at high velocities are richly illustrated.

3. *Structure and composition* of both stony and metallic specimens, and their bearing on the origin of meteorites.

4. *Shapes.* Three thousand complete specimens may be measured and studied by advanced students with proper references.

5. *Disruption* of aerolites during flight and the problem of the total weight of annual meteoritic accretion.

6. *Probable sizes* of ordinary "shooting stars."

7. *Distribution* of meteorites of a shower and its relation to the magnitude of the parent mass, the nature and cause of the disruptions, the depths of penetration for various members, and so forth.

8. *Average probable composition* in space, in meteoric displays, arriving on the soil, compared to the earth's composition.

9. *Meteoritic oxides* and their significance to astronomers and geologists.

10. *Lunar craters* and meteorites.

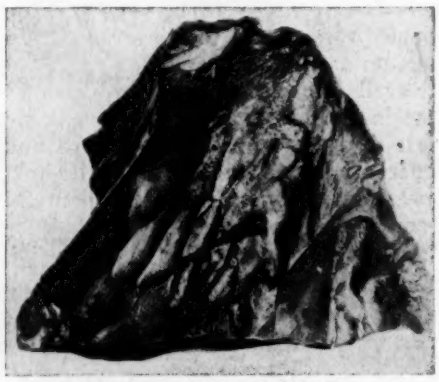
11. *Lunar craters* and tektites.

12. *Ballistic* implications in the forms of certain meteorites.

13. *Influence of meteorites* on the lives of primitive peoples.

14. *Meteorite craters.* Their present known distribution, the probable abundance of concealed craters, their geological significance, their relation to regional mineralization.

In order for visiting groups to receive lectures on any of the above subjects, arrangements should be made some weeks in advance, if possible, and at least a tentative date set. Guided excursions to Meteor Crater can also be arranged, if desired.



A "streamlined" nickel-iron meteorite, on display in the American Meteorite Museum. It shows to an exceptional degree the erosive effect of friction with the atmosphere during its fall to earth.

TERMINOLOGY TALKS-

J. Hugh Pruett

ON THE EARTH and in the sky we often indicate a general location by stating its approximate position in relation to some prominent and well-known object. But for greater exactness both terrestrially and celestially other methods must be used. Most persons are quite familiar with the geographical co-ordinates, latitude and longitude, a system based on angular distance above and below a principal plane, the earth's equator, and east and west of a selected great circle at right angles to the equatorial plane. There are similar systems for locating apparent positions in the sky; we shall discuss two of these.

The Altazimuth System

The poles of this system, determined by observation with a plumb line, are the points overhead and beneath, the zenith and the nadir. The principal plane midway between these poles is the horizon, and *altitude* is measured above and below it; thus, an altitude of 50° for Vega indicates that the star appears at this angular height above the true horizon. But to be definite about Vega's position, we must also give its *azimuth,* that is, its horizontal distance from the celestial meridian, the great circle passing through the zenith, nadir, and the north and south points of the horizon.

Astronomers generally measure azimuth from the south and count around toward the west. A star halfway up the sky and due west is at altitude 45° and azimuth 90°. If it is due north, its azimuth is 180°; if east, 270°. Civil engineers and navigators, however, use north as their zero of azimuth, and count around in the same clockwise direction. East has then an azimuth of 90° as compared with 270° with the astronomers. Frequently, too, azimuth (*bearing* to the navigator) may be expressed as distance east or west of the north point, instead of all the way around the horizon in one direction.

The complete altazimuth system applies also beneath the sky line. Altair, when 20° below the horizon, has an altitude of −20°.

The Equatorial System

A given altitude and azimuth are correct from only one point on earth, the observer's own position. And since the celestial sphere seems constantly to be turning westward, each *celestial* body has a particular altitude and azimuth for only an instant of time. The sky is restless and "always on the go." So is the earth itself, but the meridians of longitude and parallels of latitude —

(Continued on page 158)

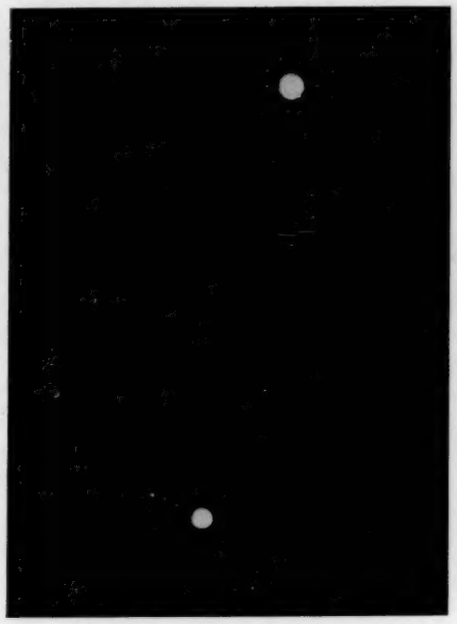
TWENTY-NINE SATELLITES*

By Clarence A. Atwell, *Amateur Astronomers Association of Pittsburgh*

WHO DISCOVERED the moon? That is about the same as asking, "Who discovered the planet Earth?" The answers to these questions are obvious. No one who ever lived on earth could rightly claim such a discovery. The earth's satellite without doubt is the object most commonly gazed at in the entire list of heavenly bodies, and until 338 years ago held the distinction of being the only known satellite.

When Galileo, in January of 1610, turned his telescope to the planet Jupiter, he saw for the first time its four brightest satellites, but he did not know whether these points of light were satellites or stars that just happened to appear close to the planet. Nightly recordings of their positions convinced him that they belonged to Jupiter and were revolving about it, in a plane almost parallel to his line of vision.

Then it was that an era of discovery began which has brought the total number of known satellites in the solar system to 29. There must have been thrills connected with each new discovery, but probably none greater than Galileo's. He saw in Jupiter's system a confirmation of the Copernican idea of the mechanism of the solar system, and his observations aroused the desire of astronomers to find more heavenly bodies then unknown. Discoveries of the other satellites came in groups: 1655 to 1684, 1787 to 1789, 1846 to 1851, and 1877 to 1948. New planets, new telescopes, the advent of photography, and better observing methods were among the causes that suddenly opened up the opportunities to make these groups of discoveries.



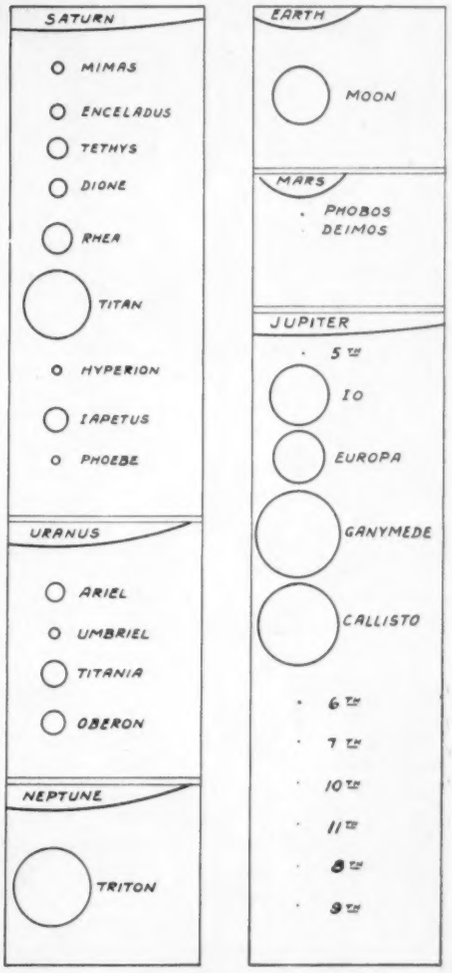
This photograph by E. E. Barnard shows Venus (above) and Jupiter with its four bright moons, in numerical order outward from the planet. Yerkes Observatory photo.

It seems natural to start a more detailed discussion of these satellites with our own, the moon. It is such a large neighbor that if viewed from Mars the earth and the moon together would surely be classed as a double planet, something not seen elsewhere in the solar system. Many voyagers on the earth's surface have traveled more miles than from here to the moon, especially aviators in recent years. This nearness of the moon makes us conjecture what the surfaces of other satellites may be like. The others must have lost practically all of their atmospheres, as the moon has, because of their small masses and low surface gravity. There is probably no more weather on most of the other satellites than on the moon, although the presence of an atmosphere on Titan, Saturn's largest satellite, is definitely established, and some of Jupiter's bright moons may have observable gaseous envelopes. Without "air" however, there can be no wind, no rain, no atmospheric storms, no life or disturbance except sudden and extreme changes of temperature when the sun rises and sets, and occasional falling meteorites.

Another fairly common characteristic is that in many cases a satellite presents the same face to the planet as it revolves about it. Strictly speaking, this is caused by the periods of the satellite's revolution and rotation being equal. If the moon were viewed from a point in space, all of its surface would be seen during the time of one revolution around the earth. This corresponds to one rotation of the moon on its axis, but as seen from the earth the moon doesn't appear to rotate at all. Many other satellites are known to face their primary planets in this manner.

Our satellite is larger in proportion to its primary than any of the others. It is approximately one fourth of the diameter of the earth, while the nearest approach to this ratio is for Triton, which is roughly 1/15 the diameter of Neptune. On the other hand, Jupiter is some 9,000 times the diameter of its smallest satellites.

Since we started with the earth's



Twenty eight of the satellites of the solar system and segments of their parent planets are shown here to scale; one inch equals 14,500 miles. They are in the order of their positions from their planets but the distances are not to scale. Diagram by the author.

HARVARD COLLEGE OBSERVATORY

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New Satellite to Uranus. — Dr. Gerard P. Kuiper reports from the McDonald Observatory, "A new satellite, of the 17th magnitude, was found to the planet Uranus on a plate taken February 15 at the Cassegrain focus of the 82-inch telescope; it was confirmed on two plates taken on March 1. The distance to the planet is about 0.64 of that of Ariel, the innermost of the four previously known satellites, or about 9″. Its period of revolution has not yet been determined but may be expected to be about 30 hours. The object could not be seen visually but is readily photographed (exposure times 2 or 3 minutes)."

HARLOW SHAPLEY

1948 March 9

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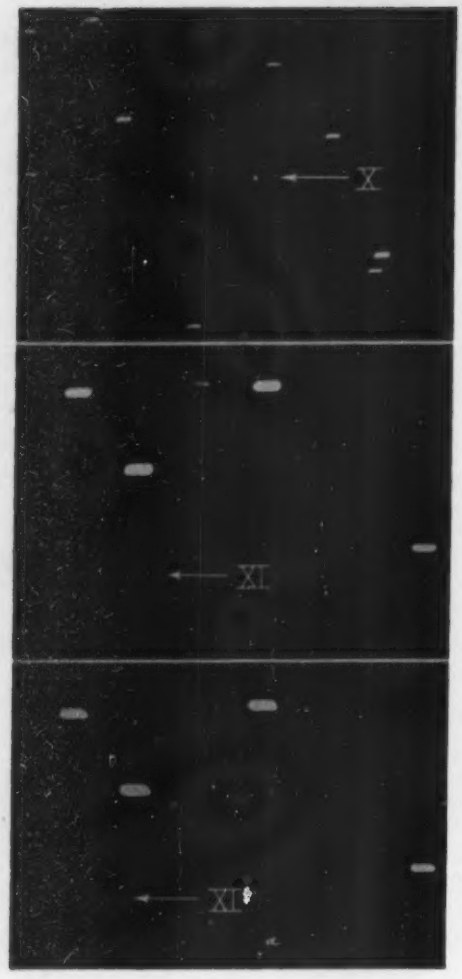
*ED. NOTE: Mr. Atwell's title and some of the material in this article have been revised in press to conform with the recent discovery of a fifth satellite of Uranus at the McDonald Observatory of the University of Texas.



Jupiter's latest known satellites, photographed with the 100-inch telescope by Seth B. Nicholson. The lower two pictures are the discovery plates of XI, on July 30, 1938, and show its motion relative to the background stars. Mount Wilson Observatory photo.

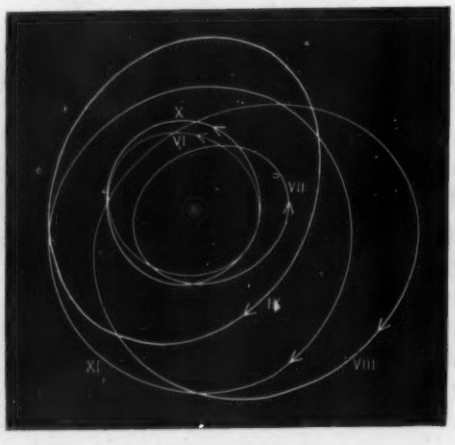
moon, and Mercury and Venus have none, let us proceed outward from the sun, planet by planet rather than in the order of discovery. Until as recently as 1877, authors and poets often wrote about "moonless Mars." Herschel had searched for Martian satellites before this date but had been unable to find any. His failure was due to the extreme proximity of Mars' two tiny satellites to the glare of the planet. In 1877, Asaph Hall made use of the new 26-inch refractor at the U. S. Naval Observatory to locate the two satellites which he called Phobos and Deimos (Fear and Panic) at the suggestion of a friend. In Greek mythology, these were the names of the children of Mars, the god of war, and Venus.

The innermost, Phobos, moves at the fearsome rate of one revolution in seven hours and 39 minutes, less than one third the time it takes Mars to rotate on its axis. This gives the curious result of Phobos rising in the west and setting in the east, as seen from the surface of Mars. Phobos skims along only 3,700 miles above the surface of the planet. Deimos is farther away from the planet and revolves once every 30 hours and 18 minutes. Since this is comparatively so near the 24-hour 37-minute rotational period of the planet, Deimos has a very slow apparent motion through the Martian sky, remaining in the sky over two days between rising in the east and setting. Phobos is estimated to be 10 miles in diameter, and Deimos, five.

After Galileo saw Io, Europa, Ganymede, and Callisto, Jupiter's four bright satellites, 282 years passed before another of the present total of 11 was seen. Then at Lick Observatory Barnard discovered the fifth, faint and nearer Jupiter than the first four. This satellite is next to Phobos in shortness of its period of revolution, but it is like Deimos in being a slow-motion object in the sky of Jupiter, as the planet rotates in about one sixth less time than the fifth satellite revolves.

After Jupiter V, all the remaining six satellites were discovered photographically in the 20th century. Perrine located VI and VII at Lick in 1904 and 1905, and Melotte found VIII at Greenwich Observatory in 1908. Nicholson discovered IX on a photographic plate taken at Lick in 1914. These last two have the largest orbits of all the satellites, nearly 15 million miles from Jupiter, and their periods are measured in years. They have the added distinction of retrograde motion, revolving from east to west in their orbits.

Finally, in 1938, Nicholson discovered two more Jovian satellites by making long photographic exposures with the 100-inch telescope at Mount Wilson Observatory. XI has an orbit similar to VIII and IX, and retrograde motion. All except the Galilean satellites of Jupiter are fainter than the 12th magnitude, and not well suited for observation in the ordinary amateur's telescope. The four bright ones, however, have been and will continue to be the amateur's delight. Eclipses, occultations, transits, and shadows on the surface of the planet are quite frequent and present a continuous bright panorama for observation with small telescopes.



The orbits of Jupiter's satellites are here seen from the north. Note the three retrograde motions. Model photo by Mount Wilson Observatory.

SATELLITES OF THE SOLAR SYSTEM

Name	Stellar Mag.	Mean Dist. from Planet		Revolution Period			Diameter Miles	Discoverer
		" *	Miles	d	h	m		
SATELLITE OF THE EARTH								
Moon	−12.6	530	238,857	27	07	43	2160	
SATELLITES OF MARS								
Phobos	12	8	5,800	0	07	39	10?	Hall, 187
Deimos	13	21	14,600	1	06	18	5?	Hall, 187
SATELLITES OF JUPITER								
V	13	48	112,600	0	11	57	100?	Barnard,
Io	5	112	261,800	1	18	28	2300	Galileo, 1
Europa	6	178	416,600	3	13	14	2000	Galileo, 1
Ganymede	5	284	664,200	7	03	43	3200	Galileo, 1
Callisto	6	499	1,169,000	16	16	32	3200	Galileo, 1
VI	14	3037	7,114,000	250	16		100?	Perrine, 1
VII	16	3113	7,292,000	260	01		40?	Perrine, 1
X	18	3116	7,300,000	260			15?	Nicholson 8
XI	18	5990	14,000,000	692			15?	Nicholson 8
VIII	16	6240	14,600,000	739			40?	Melotte, 1
IX	17	6360	14,900,000	758			20?	Nicholson 1
SATELLITES OF SATURN								
Mimas	12	27	115,000	0	22	37	400?	W. Hersc 789
Enceladus	12	34	148,000	1	08	53	500?	W. Hersc 789
Tethys	11	43	183,000	1	21	18	800?	G. Cassini 4
Dione	11	55	234,000	2	17	41	700?	G. Cassini 4
Rhea	10	76	327,000	4	12	25	1100?	G. Cassini 2
Titan	8	177	759,000	15	22	41	2600?	Huygens,
Hyperion	13	214	920,000	21	06	38	300?	G. Bond,
Iapetus	11	515	2,210,000	79	07	56	1000?	G. Cassini
Phoebe	14	1870	8,034,000	550			200?	W. Picker 898
SATELLITES OF URANUS								
Ariel	16	14	119,000	2	12	29	600?	Lassell, 1
Umbriel	16	19	166,000	4	03	28	400?	Lassell, 1
Titania	14	32	272,000	8	16	56	1000?	W. Hersc 787
Oberon	14	42	364,000	13	11	07	900?	W. Hersc 787
SATELLITE OF NEPTUNE								
Triton	13	16	220,000	5	21	03	3000?	Lassell, 1

*As seen from the sun.

This table is reproduced from the "Observer's Handbook" of the Royal Astronomical Society of Canada.

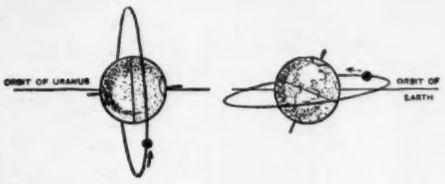
As a possessor of satellites, Saturn is almost equal to Jupiter, having a total of nine. Simon Newcomb records the story that when Huygens discovered the brightest one, Titan, in 1655, he said the solar system was then complete, as there were seven large bodies (the sun and the six known planets) and seven small bodies (the moon, Jupiter's four moons, Saturn's ring, and Titan). Huygens thought this lucky — evidently even though an astronomer he was still a believer in some of the ancient astrological ideas. But the magic number idea was broken shortly when Cassini found a second satellite of Saturn in 1671, another in 1672, and then, in 1684, two more. Herschel found the next two, and the Bonds and Pickering at Harvard found the eighth and ninth, respectively. Phoebe is some 200 miles in diameter, and has a retrograde motion. Pickering also announced a 10th satellite of Saturn in 1905, and some books have even listed it under the name of Themis, but it has never been officially confirmed.

Saturn's satellites, like those of Jupiter, cover a wide range of sizes, periods, and orbits, but none is of the extremely small size of Jupiter's VII to XI. Iapetus, one of the brighter, appears five times as bright at its western elon-

gation as at eastern. This is explained by the fact that its reflecting power on one side is much greater than on the other.

The satellites bear names of the brothers of the mythological god Saturn. At least five of Saturn's satellites are interesting objects in moderate-sized telescopes, and their positions are predicted in the *American Ephemeris*.

For Uranus, we find a surprising variation not yet noted, for the orbits



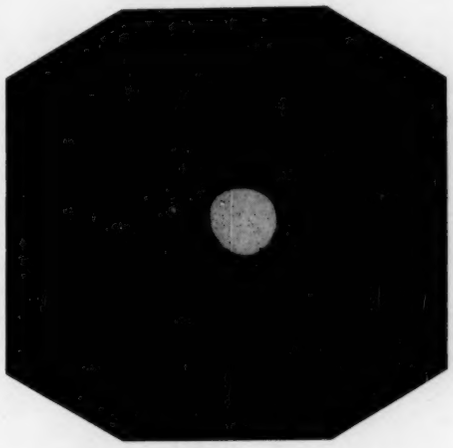
Here the inclination of the orbit of the earth's moon is compared with that of Uranus' satellites. (From "Splendour of the Heavens.")

of its four named satellites are almost at right angles to the plane of the ecliptic, 98 degrees. This gives a peculiar effect as viewed from the earth. At two places in the orbit of Uranus about the sun, the orbits of these satellites appear almost circular to us; at intermediate positions, they appear almost on edge, and the satellites seem to move up and down on a line through the planet. At present, the orbital plane is nearly flatwise to us, and the next few years will be good for observing these very distant and faint objects of the solar system. The orbits will be edgewise again in 1966.

In order of distance from Uranus, the named moons are Ariel, Umbriel, Titania, and Oberon. The outer two were found by Herschel in 1787, after which he thought he could see four others, and for many years six satellites were listed for this planet. No one proved or disproved their existence until Lassell built two large reflecting telescopes, one two feet, and another four feet in diameter, in 1845. He found that Herschel was mistaken about the four, but that there were two others so close to Uranus that they could not have been seen by previous instruments. Inasmuch as it requires considerable skill to get a good photograph of the satellites of Uranus even with modern large telescopes, it is little wonder that Herschel was not certain of what he saw visually.

Soon after the planet Neptune was discovered in 1846, astronomers of all the great observatories made observations of it. In that same year Lassell found that Neptune has one satellite with a period of five days, 21 hours, and retrograde motion.

Some have proposed the capture theory, whereby it is thought that the three retrograde satellites of Jupiter and one of Saturn may once have been asteroids that strayed too close to one of these large planets and were actually taken out of their paths around the sun. R. A. Lyttleton (The SKY, May, 1940) has advanced a different theory for Triton. He suggests that the planet Pluto, comparable in size with Triton, once may have been a second Neptunian satellite. Gradual changes in the diameters of their orbits may have caused them to come near enough to each other to cause extremely disturbing results to both. The result he suggests is that Pluto was driven away from Neptune to begin an independent orbit around the sun, and that Triton's motion about Neptune was reversed from its original normal direction.



Triton and Neptune (the planet overexposed). Yerkes Observatory photo.

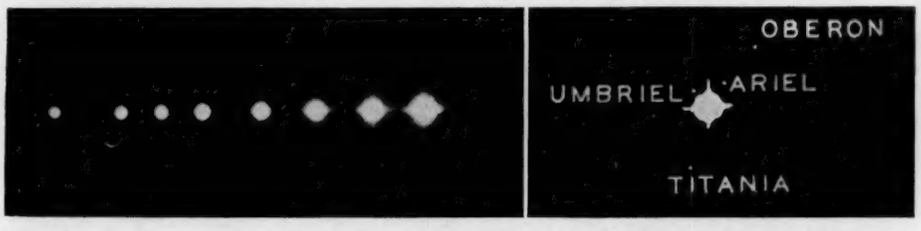
Satellites have helped unfold the mysteries of the universe. Observing the apparent periods of Jupiter's four bright satellites led Roemer in 1675 to demonstrate the speed of light traveling across the spaces of the solar system. It is necessary to measure only the period of a satellite and its distance from the planet to have the data for calculating the mass of the planet and satellite combined. Satellites also provide a means of measuring the oblateness, or equatorial bulge, of a planet. Triton's orbit is inclined 20 degrees to Neptune's equator, and in a 600-year period the axis of this orbit describes a nearly conical motion with respect to Neptune's axis. This motion is caused by the attraction of the planet's equatorial bulge.

This imaginative painting by Howard Russell Butler shows Mars as it may appear from Phobos, its inner moon.

It is interesting to think of what the planets would look like if viewed from their satellites. To see the earth from the moon would give one an entirely new viewpoint and impression of our world. An object in the black lunar sky, four times the diameter and 16 times the area the moon presents to us, planet Earth would possess a color scheme of great beauty. The continents and islands would look as on a library globe but with bright seasonal changes of green, brown, and white, seen between stretches of constantly changing cloud coverings. The polar caps of white would vary greatly in size with the seasons. At full phase of the earth, the blue oceans would often show a brilliant spot of light where the sun's image would be reflected as from a convex mirror.

If Mars were seen from Phobos, it would extend almost half way from the horizon to the zenith of the observer. Jupiter and Saturn with its rings would present astounding sizes in the sky when seen from their near satellites, reflecting sunlight with great brilliance. From its outer three moons, 15 million miles away, Jupiter would have an apparent diameter three times that of the sun, but only three fifths the size of the sun or moon as we see them from the earth.

The study of satellites is by no means a cold and lifeless subject. The title of this article will no doubt some day be out of date as astronomers continue to examine photographic plates for additional small elements of the solar system.



A series of increasing exposures of Uranus and the four satellites known to belong to it in 1931, when the picture was taken at Lick Observatory. The faint satellite images are identified at the right.

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BOOKS AND THE SKY

AN OUTLINE OF STELLAR ASTRONOMY

Peter Doig. Hutchinson's, London, 1947. 168 pages. 10s 6d.

TWENTY YEARS AGO a concise and refreshing little volume from the pen of Mr. Doig summarized our knowledge of the sidereal universe. Now its successor has appeared and reflects in many ways the great advances made in stellar astronomy during two decades. Physically the book under review requires about the same number of pages, tables, and appendices as its predecessor to accomplish its aim. It is somewhat unfortunate that the quality of paper available for this edition is not better — the photographs have suffered particularly in reproduction. One may overlook these defects, however, in the enjoyment of the material presented.

The book is divided into three parts: I. The Individual Star-Observational Data; II. The Nature of a Star; III. The Stellar Universe. The first of these deals with the luminosities, masses, dimensions, motions, and space distribution of the stars. Binary stars, variable stars, and novae are also treated. A wealth of the most recent data is summarized in tabular form and in description. Galactic rotation effects on the velocities of the stars and interstellar absorption effects on their magnitudes are discussed. The recent work of the Dutch investigators concerning the nature of interstellar matter is summarized. These last two items embrace the most outstanding developments of the last 20 years in studies of the galactic system.

The general excellence of Doig's summary precludes any but minor criticisms of this section of the book. One might wish that in the references at the end of Chapter I, for example, more distinction had been made between the types of treatment given in Eddington's **Internal Constitution of the Stars** and in Goldberg and Aller, **Atoms, Stars and Nebulae.** And in Table 4 on page 15, it would seem appropriate to use star designations such as Barnard's star, Kapteyn's star, which are more commonly encountered than Munich 15040 and Cordoba $V^h 243$.

Section II deals with stellar atmospheres, interiors, and evolution. A descriptive treatment of excitation and ionization processes is given, which might have been enhanced, in the reviewer's opinion, by the addition of a simple energy level diagram. A statement would be welcome to the effect that the closed shells of electrons in the Bohr theory are associated with stability of the atom in its reaction to energizing radiation.

The Bethe-von Weizsaecker theory of energy generation in stellar interiors is given on page 81 but makes no reference to these ingenious originators. Here, also, a diagram showing the carbon cycle and the parts played by carbon, nitrogen, and oxygen would have enhanced the discussion.

Ideas concerning stellar evolution, past and present, conclude this part of the book. The reader is left, quite correctly, with the impression that evolutionary theories of stellar formation are still in a state of flux. The pulsation theory to account for Cepheid variation is admirably described.

In the final section of the book, the structural details of the Milky Way system are presented. The parts played by galactic and globular clusters, obscuring clouds of interstellar matter, and galactic nebulae, in the general evolution of ideas concerning our galaxy are clearly portrayed. Star counts and added distributions of spectral types will undoubtedly contribute greatly to the picture in the future. We note that the unique observational advantages provided by the Schmidt-type telescope in studies of galactic structure are not mentioned.

A chapter on external galaxies concludes the descriptive part of the book. In this the author gives a very clear description of present knowledge concerning the external galaxies, together with more detailed information about a few outstanding members of the local system of galaxies, such as the Andromeda nebula, the Magellanic Clouds, and others. Baade's work on the types of stellar population predominating in the central regions and in the spiral arms of the galaxies is mentioned. The results of the extensive surveys on the distribution of the galaxies by Hubble and by Shapley emphasize the large-scale homogeneity pointed out by the former and the small-scale clustering tendencies found by the latter. One may note a minor error on page 127 in ascribing the northern Harvard survey to an 18-inch

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692 Pages **1947** **$4.75**

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telescope rather than to the 16-inch Metcalf. In concluding this chapter, the author discusses evidence for the long and short time-scales in estimates of the age of the universe.

Twelve appendices, which give added and more detailed numerical data relative to such things as the period-luminosity relation, the interrelationships of bolometric, absolute, photovisual magnitudes, spectral type characteristics, and so on, conclude the book.

One may summarize impressions of this book by the simple ejaculation, "Excellent reading, an amazing fountain of information!"

S. W. McCUSKEY
Case Institute of Technology

SUN, STAND THOU STILL

Angus Armitage. Henry Schuman, Inc., New York, 1947. 210 pages. $3.00.

IT IS COMMON PRACTICE for those interested in astronomy to tell one another that much gratification of the spirit rewards those who taste the heritage of the science — its history and tradition. Then they usually recommend to each other some out-of-print volume noted for its small type, and the matter is dropped.

Here, however, in handsome format, is the most readable book in the history of astronomy to appear in some years. Dr. Armitage, of London, has produced a modest treatise on the advent and acceptance of the heliocentric system coupled with an authoritative short life of Copernicus which carries the reader through a considerable sweep of astronomical background.

It is, of course, a guided tour at a giddy pace, for only the central figure can receive full treatment, but the first part, "Astronomy before Copernicus," sets the stage in 16,000 neatly chosen words. The last part, "The Triumph of the Copernican Theory," brings the story down to Bessel's trigonometric parallax of 61 Cygni in 1838. From there on the textbooks and popular works quite properly take over.

The happy result is that the reader gets his history in the modern painless manner and he gets the truth, as we know it, from an established authority. This is the second work on the great Pole by Angus Armitage, whose **Copernicus, the Founder of Modern Astronomy** (London, 1938) was written more for the student, with particular emphasis on the actual content of **de Revolutionibus.** Americans will note that our top scholar in the field, Edward Rosen, "made valuable criticisms and suggestions" while the present volume was in typescript.

Sun, Stand Thou Still is written to accommodate those innocent of astronomical terminology. The author takes a dozen words to avoid calling Copernicus' first observation an occultation. This gentle handling of outsiders should not, however, mislead the initiated. What he says ought to be part of their background and even where material proves familiar, the felicitous presentation drives it home. Moreover, for those who would go deeper, there is a three-page bibliography with helpful comments.

The picture of Copernicus is well balanced. He is represented as a man of political importance in turbulent times, an administrator, economist, and physician, an astronomer only in his spare time. He is drawn as a powerful and lonely character, tolerant and loyal in the midst of religious strife. Correct emphasis is laid on the "choice" and logical argument for, rather than the "discovery" of, the heliocentric theory.

In **Sun, Stand Thou Still** the amateur will find a stimulating supplement to his astronomical reading—a book full of sound scientific record painted in the strong colors of Reformation days. The student will find it rewarding, a likely favorite for outside reading in first-year astronomy courses.

This book is not just "a welcome addition" or "deserving of a place on your bookshelves." Within its appointed limits, it is a triumph.

JOHN W. STREETER
Harvard College Observatory

THE LIFE AND TIMES OF TYCHO BRAHE

John Allyne Gade. Princeton University Press for the American-Scandinavian Foundation, Princeton, N. J., 1947. 209 pages. $3.50.

THE PREFACE of this little book begins: "The year 1946 marked the four-hundredth anniversary of the birth of one of Scandinavia's greatest scientists, Tycho Brahe. These pages are thus intended as a quadricentennial tribute to the man, together with a description of the times in which he lived."

The author could have said that Tycho was also one of the world's greatest astronomers. His life was certainly one of the most interesting. Mr. Gade's book not only gives the reader an intimate knowledge of the life and work of Tycho, but adds information concerning the difficult political days in which the great astronomer lived.

Free use is made of the standard work in English entitled **Tycho Brahe** by J. L. E. Dreyer, published in 1890, for which acknowledgment is given. Dreyer was also the editor of a 15-volume set of the works of Tycho, published 1913-1929, mostly in Latin and Danish. Dreyer's book about the life of Tycho contains more detailed information about Tycho's estate on the island of Hveen and of his residence and observatories than does this book of Mr. Gade's. Dreyer also places greater emphasis on Tycho's astronomical work.

However, **The Life and Times of Tycho Brahe** is more readable and should be enjoyed by the average reader whether or not he is familiar with the history of astronomy. Several of Tycho's instruments are mentioned, and there are illustrations of the great quadrant, the five-foot globe, the mural quadrant at Uraniborg and the

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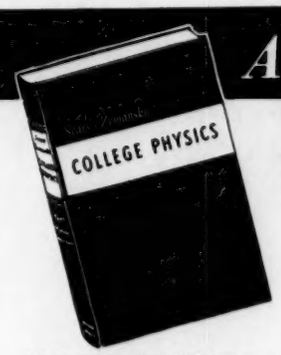

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Teachers of college physics who have regretted that they were unable to adopt the three-volume series of Sears' PRINCIPLES OF PHYSICS because of its use of calculus throughout, will welcome this adaptation and revision by Professor Mark W. Zemansky of the College of the City of New York.

Those parts of the original text that came within the scope of intermediate physics and which were therefore treated with the aid of calculus, have been either removed or rewritten in simpler form. COLLEGE PHYSICS consists exclusively of material suitable for first-year college students whose mathematical preparation goes no further than algebra and the elements of trigonometry. The total number of topics has also been reduced so that a complete course in general physics may be covered in one year.

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armilla from Stjerneborg. But these instruments are not described in detail in the text.

The author traces briefly the early years in the life of Tycho: his birth to noble parents, his education by an uncle, and his years at the University of Copenhagen, where at the age of 13 he decided against a life in the service of the government as expected by his parents. The greater part of the book describes Tycho's education in astronomy, his travels in Europe and the establishment of the estate on Hveen, and emphasizes his disagreeable nature, his quarrels with the young king of Denmark over finances, and finally his decision to move from Denmark to Germany.

The last years spent in exile are interestingly described. Letters are quoted from Tycho to the king of Denmark in which the astronomer suggested that he would be willing to return; and the king's reply that the fault was entirely Tycho's, citing the disrespect of the subject for the king and his lack of regard for orders. The result was that Tycho never returned to Denmark, but did find a friend and benefactor in Rudolph II of Germany.

The last chapter, "Tycho's Last Days," describes the death and burial of the great man. It includes a footnote concerning the exhuming of the bodies of Tycho and his wife Kirstine in 1901, 300 years after they were buried. But more important astronomically there is an account of the relations between Tycho and Kepler, contrasting the two men and pointing out how the work of each enhanced the work of the other.

The text ends with the following paragraph: "In his **Astronomiae instauratae mechanica** Tycho wrote that he considered his Hveen accomplishments to be 'the improved elements of the solar orbit, the discovery of a new inequality in the moon's motion, the variability of the inclination of the lunar orbit and the motion of the nodes, the observation of accurate positions of a thousand fixed stars, the explosion of the time-honored error about the irregularity in the precession of the equinoxes, the accumulation of a vast mass of carefully planned observations of the planets, in order to have new tables of their motions constructed, and the observations of comets, proving them to be much farther from the earth than the moon.' This was indeed a record of gigantic achievement, which, if only Denmark had recognized its value and size, would have made her forgive Tycho's shortcomings and consider only the extraordinary fruits of his genius and tireless energy."

There is a short appendix giving a "Brief Account of Tycho's Offspring" and a bibliography of publications in English, Latin, Danish, and other European languages, about Tycho and some of his contemporaries.

The book seems accurate and is well written. A few hours spent with it gives an intimate glimpse of this romantic period of 300 years ago, and a vivid picture of a great astronomer.

C. M. HUFFER
Washburn Observatory

NEW BOOKS RECEIVED

PHOTOGRAPHIC GIANTS OF PALOMAR, *James S. Fassero*, 1947, *Westernlore Press*, Los Angeles. 60 pages. $1.59.

The chief contents of this spiral-bound booklet are 20 of the famous Russell W. Porter drawings of the 200-inch telescope and the Palomar Schmidt camera, with captions by a staff member of the Caltech astrophysics laboratory. Excellently reproduced in large size, the drawings provide a graphic tour through Palomar's great giants.

ATOMICS FOR THE MILLIONS, *Eidinoff* and *Ruchlis*, 1947, *Whittlesey*. 281 pages. $3.50.

A non-technical book designed to cover the basic principles and development of our knowledge of atomic energy, so that the layman may "properly understand this atomic age in which we live."

COLLEGE PHYSICS, *Sears* and *Zemansky*, 1948, *Addison-Wesley*. 848 pages. $6.00.

This physics textbook, of 49 chapters covering mechanics, heat, sound, electricity and magnetism, optics, and atomic physics, is based on Sears' three-volume *Principles of Physics*. It has been rewritten and simplified so that algebra and elementary trigonometry are the only mathematical background necessary. Answers to some of the problems are given.

CAUSES OF CATASTROPHE, *L. Don Leet*, 1948, *Whittlesey*. 232 pages. $3.00.

One of the science-for-the-layman series chosen for honorable mention in the Whittlesey House-*Science Illustrated* fellowship contest, this book discusses earthquakes, volcanoes, tidal waves, and hurricanes, describing them, and explaining something of the underlying causes of such phenomena.

TERMINOLOGY TALKS

(Continued from page 152)

drawn on its surface in imagination — go with it. Nashville is unable to escape from latitude 36° north, longitude 87° west, but as seen from Nashville every star is changing its altitude and azimuth constantly. Therefore, we need a system of celestial co-ordinates in which a star's position is relatively fixed, just as cities on the earth are in fixed latitudes and longitudes.

We have such a system in the sky in equatorial co-ordinates. In this plan the celestial poles and equator on the sphere of the heavens correspond to those of like name on the earth (see the January and February Talks). Latitude and longitude on the earth are matched by *declination* and *right ascension* in the sky. The celestial equator serves as the primary plane, and distance north and south of it is the declination (abbreviated Dec.). We may then state that the declination of Capella is 46° north or +46°, and that of Sirius is 17° south, or −17°. This indicates that these positions "decline" or "deviate" from the equator by these amounts.

The other great circle is the *equinoctial colure*, which term is not bad at all after a little explanation. We recall that the apparent annual path of the sun among the stars, the ecliptic, is inclined by 23½° to the equator and cuts across it at two places 180° apart. These crossings are the vernal and autumnal equinoxes (some prefer to call them the March and September equinoxes). Now, if we draw a circle all around the celestial sphere so that it goes through both poles and both equinoxes, we have the equinoctial colure. The half of this great circle on the side of the vernal equinox corresponds to the meridian of Greenwich on the earth.

Although terrestrial longitude is measured both east and west of the Greenwich meridian, and labeled east or west, in the celestial equatorial system the angular measurement is eastward only from the colure. The angular distance of a star east of the vernal-equinox side of the colure is its right ascension (abbreviated R. A.). It may be designated either in degrees or hours. Completely around the sky parallel to the equator is either 360° or 24 hours of R. A. Regulus is about 150° east of the equinoctial colure, so, if stated in hours, it is at about 10^h R. A. This, together with its declination of about 12° north, locates that star (approximately) on the celestial sphere.

It may be puzzling why such a term as right ascension ever came into use. Ascension means rising, or going up. In earlier times, oblique ascension, and both right and oblique descension, were also used, but only one of all these has survived. Considering the right sphere seen from the earth's equator (last month's Talk), where all heavenly bodies on rising ascend the eastern heavens at right angles to the horizon, the right ascension of any star is given by the altitude of the vernal equinox (on the right sphere) from the true eastern horizon at the time the star is just rising on this horizon. When Hamal, brightest star in Aries, is rising at Cayambe (latitude 0° near Quito, Ecuador), the vernal equinox is about 30° above the horizon and has been up two sidereal hours. So we state that the right ascension of Hamal is 30°, or 2^h.

A SOLAR INFRARED REFLECTING SPECTROMETER

(Continued from page 144)

measure of the overlapping visual order at the sought-for infrared wave length. Multiplying by the order number of the visual spectrum yields the infrared wave length directly.

There are almost no laboratory standards for aiding the identification of atomic lines longer than 20,000 angstroms, but we have observed the third member of the Brackett series of hydrogen at 21,655.2, and the two sodium lines at 22,052.7 (predicted) and 22,079.4 (predicted). This pair of lines has been observed in emission in the laboratory. Measurements of wave lengths and identifications of solar atomic lines are being made, and we hope to complete a list of solar lines extending to 25,000 angstroms.

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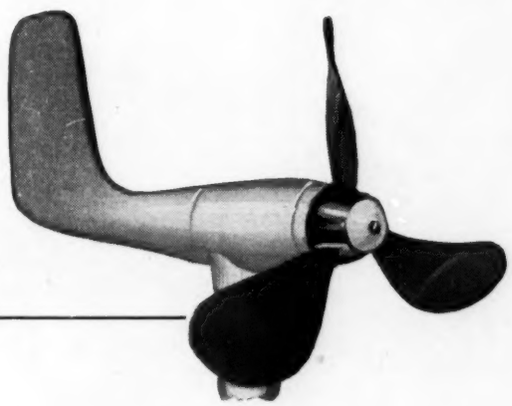

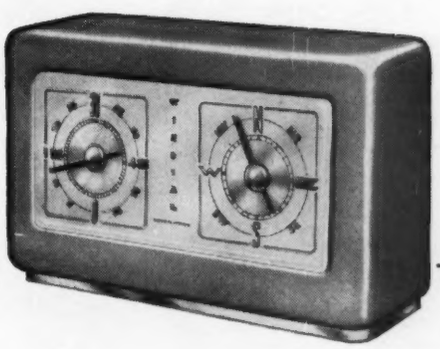

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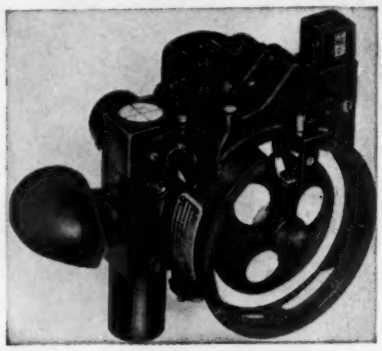

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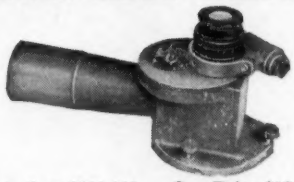

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A NULL TEST FOR PARABOLOIDS

MOST of the telescope making fraternity in this country are familiar with the name of H. E. Dall, of England, who has written many papers for amateurs. He is responsible, together with Allen R. Kirkham, of Tacoma, Wash., for the Cassegrainian with spherical secondary design which has lately received much attention from amateurs (see **Sky and Telescope**, January, 1946).

The description of the following test is taken from a paper by Mr. Dall communicated to the British Astronomical Association, and published in their **Journal,** Vol. 57, 5, 201, November, 1947. Since we believe it may be of considerable interest to amateurs, we present it here in some detail.

A null test is one whereby the perfection of the mirror is determined by the absence of any irregularity in the measurement, for instance, when a knife-edge is used, it is a null test if the picture of a perfect mirror is a smooth, flat surface. The test of a spherical mirror at radius of curvature is a null test; the test of a paraboloid at focus (by use of a flat or by testing upon a star) is a null test, since if the mirror is perfect, the shadow should blank out evenly over the entire surface.

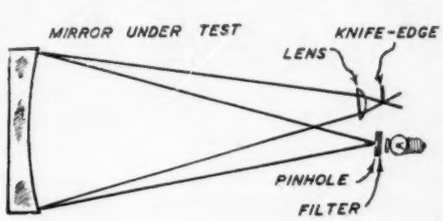
To anyone who has used a knife-edge test, it is obvious that a null test is much more satisfactory in operation than such tests as the Ronchi and Foucault at the center of curvature, since the latter tests require a great deal of personal judgment of the shadow appearances, and the making of numerous measurements which are to be compared with theoretical computations. In a null test, any irregularities in the figure show up immediately as apparently raised or depressed areas on the mirror's surface.

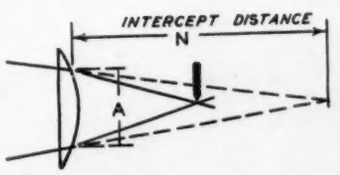
Mr. Dall does the testing at center of curvature, and the only equipment necessary in addition to the usual Foucault apparatus is a plano-convex lens of appropriate size and focal length (the requirement here is not exact), and a red filter behind the pinhole.

When a paraboloid is examined by a knife-edge at center of curvature, the shadow appearance is the result of the spherical aberration of the paraboloid. (The term is perhaps not strictly correct here, since the surface is not a sphere, but the cause is, geometrically, what is called spherical aberration in discussions of spherical surfaces.) When the zonal measurements are made by the usual Foucault methods, what is being measured is the spherical aberration of the mirror, and if this is found to correspond to the theoretical spherical aberration of the paraboloid at center of curvature (the familiar r^2/R value), then the mirror is pronounced correctly figured.

Now, if a small lens were placed in the convergent path of light to the image at the knife-edge, the spherical aberration of this lens would be combined with the aberration of the mirror, and the image seen at the knife-edge would suffer from aberration equal to their sum (algebraic). If we select the lens so that its aberration (for a specified position in the cone of light) is exactly equal in magnitude and opposite in sign to that of the mirror, the result should be a perfect image at the knife-edge, and consequently, a null test. The mirror seen from the knife-edge would have the same appearance as a sphere at center of curvature (or a paraboloid at focus).

This is the principle of the Dall test.





The arrangement of knife-edge and plano-convex lens in the null test devised by H. E. Dall. From the British Astronomical Association's "Journal."

The aberration introduced into the image by the lens will depend upon the lens position in the cone of light. Hence it is always possible to find a position for any given lens where the aberration of a particular zone cancels that of the mirror. However, in order for the progression from zone to zone to be the same as is the case for the mirror, it is necessary to remain within certain limits in the selection of the lens.

The chart and table on page 162 are for the selection of the appropriate lens and the determination of its position in the cone of rays. The focal length of the

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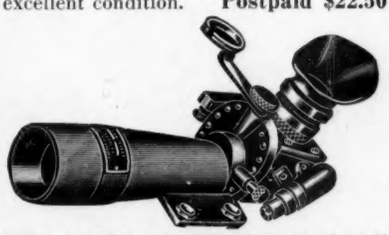
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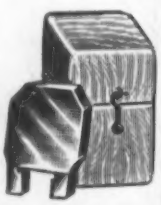

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23 mm Dia.	184 mm F.L.	coated	ea.	1.35
25 mm Dia.	122 mm F.L.	coated	ea.	1.25
26 mm Dia.	104 mm F.L.	coated	ea.	1.25
29 mm Dia.	54 mm F.L.	coated	ea.	1.25
29 mm Dia.	76 mm F.L.	coated	ea.	1.25
31 mm Dia.	124 mm F.L.	coated	ea.	1.50
31 mm Dia.	172 mm F.L.	coated	ea.	1.25
32 mm Dia.	132 mm F.L.		ea.	1.50
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RIGHT ANGLE PRISM 62 mm Face			ea.	6.00
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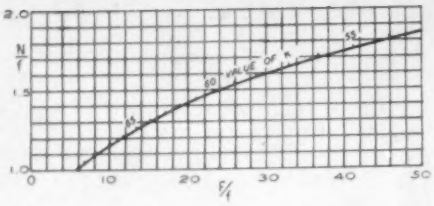

To use this graph, read values of F/f up to the curve for K, and read horizontally for the required value of N/f. This chart and the table below are from the "Journal" of the British Astronomical Association.

lens should be 10 to 15 times the total r^2/R correction of the mirror; for example, for a 12-inch f/5 paraboloid, the correction is $r^2/R = 36/120 = 0.30$ inches; hence, a plano-convex lens of three- to four-inch focal length is needed. A suitable lens might be the field lens of a Ramsden or Huygenian eyepiece; failing this, there are many thousands of war surplus lenses to be found today.

Suppose, in the example quoted, a lens is found with a focal length of 3½ inches. Image a distant light source on a white card with the plane side of the lens toward the light source. Then measure the focal length carefully **from the vertex of the convex side** to the screen. To reduce the aberrational halo and to facilitate measurement, the lens should be stopped down to about f/10 when making this focal length determination.

The chart shows the relation of **N/f** to **F/f**, where **N** is the interception distance of the lens within the cone of rays from the mirror, **F** is the focal length of the mirror, and **f** is the effective focal length of the lens, 3.5 inches in our example. Therefore **F/f** for this lens and the 12-inch f/5 mirror is 60/3.5 or 17.14. Reading upward to the curve of **K** with this value and horizontally to the **N/f** scale, we find that value to be about 1.36. The value of **N** itself is then 1.36 times 3.5, or 4.76 inches.

To obtain the proper setting of the lens, the utilized aperture, **A**, is computed as **N/2M** (with pinhole at center of curvature) where **M** is the focal ratio of the mirror, 5 in our example. Therefore **A** is 4.76/10 or 0.476 inches. This diameter is marked on the lens surface with ink spots, or a suitably **sized mask is cut** out and placed over the lens. Concentricity is very important here, and the lens should be placed so that its axis is aligned within a degree or two of the center of the mirror.

Mirror Aperture D	F. No. of Mirror	Suitable focus of lens = f.	Intercept Distance N.	Intercept Diameter A.
6-in.	F.5	2·0-in.	2·60-in.	0·26-in.
6-in	F.6	1·5-in.	2·25-in.	0·187-in.
8-in.	F.4	2·5-in.	3·11-in.	0·389-in.
8-in.	F.5	2·5-in.	3·33-in.	0·333-in.
8-in.	F.6	2·5-in.	3·50-in.	0·292-in.
10-in.	F.6	3·0-in.	4·26-in.	0·355-in.
12-in.	F.4	4·0-in.	4·88-in.	0·610-in.
12-in.	F.6	3·0-in.	4·50-in.	0·375-in.
100-in.	F.4	35-in.	42·0-in.	5·25-in.

A few examples for which Mr. Dall has computed intercept distances and diameters for suitable lenses.

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4"	$5.25	6"	$6.75
8"	$9.75	10"	$16.75
	12½"	$31.75	

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Also, pinhole and knife-edge should not have too great a lateral separation.

A good substitute for the ink marks on the lens is a tube, or a pair of telescoping tubes, the diameter of **A**, with the lens centered over one end and the knife-edge mounted at the other. This is positioned at the point where the mirror image just fills the opening of the tube at the lens end.

If the mirror is perfect, a null test will be obtained with the knife-edge; otherwise, any zonal irregularities will stand out clearly. For general overcorrection, move the lens nearer the mirror for the null effect, farther away for undercorrection. The percentage departure from the true parabolic correction will be four times the percentage change in **N**. If, in the example quoted, a null test is given with the lens shifted outward by 0.11 inch, the mirror is undercorrected by about 9.5 per cent.

To overcome the chromatic aberration of the lens, a filter is used to give reasonably monochromatic light, but not one in which too much light is lost. An ordinary red filter is best; it is placed over the pinhole. The pinhole should be brightly illuminated, and a condensing lens mounted in front of the lamp will aid here. A slit instead of a pinhole may be used if its length is kept within 0.02 inch. Recommended pinhole size is 0.001 to 0.002 inch.

The actual longitudinal aberration of the lens is given by $\mathbf{a = KN^4/M^2f^3}$, where the constant **K** is read from the curve. This curve was calculated for f/7, for which higher-order aberrations are negligible; crown glass of refractive index 1.52 and a reasonable lens thickness was used; normal lenses should not depart much from these assumed characteristics.

REFRACTOR BLANKS

Amateur telescope makers who wish to try their skill at the construction of a refracting telescope will find two specially designed sets of blanks available from Bausch & Lomb Optical Company after April 1st.

Each set will consist of three blanks, a crown, a flint, and a work glass or tool. Set A will have a diameter of 115 mm. and thickness of 20 mm.; Set B will be of 89-mm. diameter, 15-mm. thickness. Constants for these glasses are:

	N_d	V
BSC-2	1.51700	64.5
DF-2	1.61700	36.6
C-50	(work glass)	

The prices are set low to interest amateurs, $26.00 for Set A, and $14.25 for Set B. Further information can be had from the Specialty Sales Department, Bausch & Lomb Optical Co., Rochester 2, N. Y.

Some amateurs may wish to design their own lenses, a fairly lengthy job for the beginner, but by no means extremely difficult, and very interesting to anyone mathematically inclined. Refer to the series in Gleanings beginning in **Sky and Telescope,** August, 1942, and to H. H. Selby's article in **Amateur Telescope Making Advanced,** page 212. If sufficient interest is indicated by written inquiries, we may prepare a suitable set of standard curves for the above glasses at a specified f-ratio (probably f/15).

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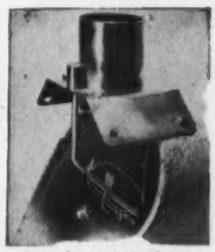

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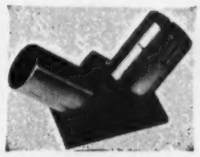

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Note **reduced** sectional view through the earth, which is only one of many drawings included on this one chart.

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OBSERVER'S PAGE

Greenwich civil time is used unless otherwise noted.

MARS' OCCULTATION IN FEBRUARY

Generally favorable weather prevailed for the occultation of Mars, visible from Canada and the northern United States on the evening of February 23rd. Most interesting among the reports received is that of John Paulson, R.F.D. No. 1, Navarre, Ohio, who writes:

"On February 23rd I saw that an occultation would occur within 45 minutes. I drove 14 miles to a friend's home and there we set up several of his telescopes. We watched Mars drawing closer to the moon's edge and we could see that if an occultation occurred the planet would go only a few minutes of arc beneath the moon's southern limb. We watched Mars come within five seconds of arc of the Leibnitz Mountains and then slowly draw away. Mars' diameter was 13 seconds, and this closest approach was surely less than one half this distance. I have observed many occultations, but this was the first time I have ever seen anything as impressive as a close graze by the moon and a planet."

At Rochester, N. Y., members of the Astronomy Section of the Rochester Academy of Sciences successfully observed an occultation lasting 27 minutes 53 seconds. Paul W. Davis sent an excellent enlargement of the moon and Mars in close approach, which space does not permit publishing. He believes he noted an increase in the size of the visible disk as the planet shone through a lunar valley about 15 seconds before its final disappearance. With the naked eye, Rochester observers distinguished the planet until about six minutes before first contact, but it was eight minutes after last contact before the planet could again be seen without optical aid. Paul W. Stevens reports that while Mars was behind the moon his group observed Saturn and its brightest satellite, Titan.

At Westwood, N. J., Bill Meyer, 85 Berkely Ave., saw a very brief occultation, about five seconds long. With 4 x 40 field glasses, the planet seemed to fade when going behind the moon and brighten when coming out. In his note, Mr. Meyer also mentions a rainbow-colored solar halo which he observed near the zenith on February 21st at about four o'clock in the afternoon.

DAYLIGHT BOLIDE EXPLODES OVER KANSAS

On the morning of February 19th all national news radio broadcasts carried appeals for precise observations of the fireball which apparently exploded nearly over Norton, in northern Kansas, at 5:01 p.m., Wednesday, February 18th. The explosion was reported as ground shaking, followed for about 10 seconds by a terrific roar. Persons over an area covering portions of six states, including Colorado, Nebraska, New Mexico, Oklahoma, and Texas, saw a very bright fireball travel across the daylight sky and explode. At Norton and vicinity a long streak of blue-gray vapor remained for about 1¼ hours after the explosion, changing its form considerably. A photograph taken by Duane W. Wray four minutes after the explosion showed considerable dissipation of the train even at that time.

Requests for good observations of altitudes and azimuths of beginning and end points of this fireball have been circulated by Oscar E. Monnig, 1010 Morningside Drive, Fort Worth, Tex., who is secretary of the Meteoritical Society. It seems very probable that fragments may be recovered somewhere near the Kansas-Nebraska line north of Norton or Norcatur, Kan.

AMERICAN RELATIVE SUNSPOT NUMBERS

Beginning with the data for January, 1948, a new method of the reduction of sunspot observations will be employed by the Central Radio Propagation Laboratory of the National Bureau of Standards. A daily American relative sunspot number has been established, the weighted mean of all observations received for which coefficients and weights have been computed. The daily observations of an individual will appear in the monthly report only when they are included in the daily American relative sunspot number. At a minimum, four months of consistent reporting are required, arbitrarily, to calculate a coefficient and weight to apply to an individual's observations. Conscientious observers wishing to make valuable observations of the sun and possessing satisfactory telescopes should communicate with Neal J. Heines, chairman, AAVSO solar division, 560 Broadway, Paterson 4, N. J.

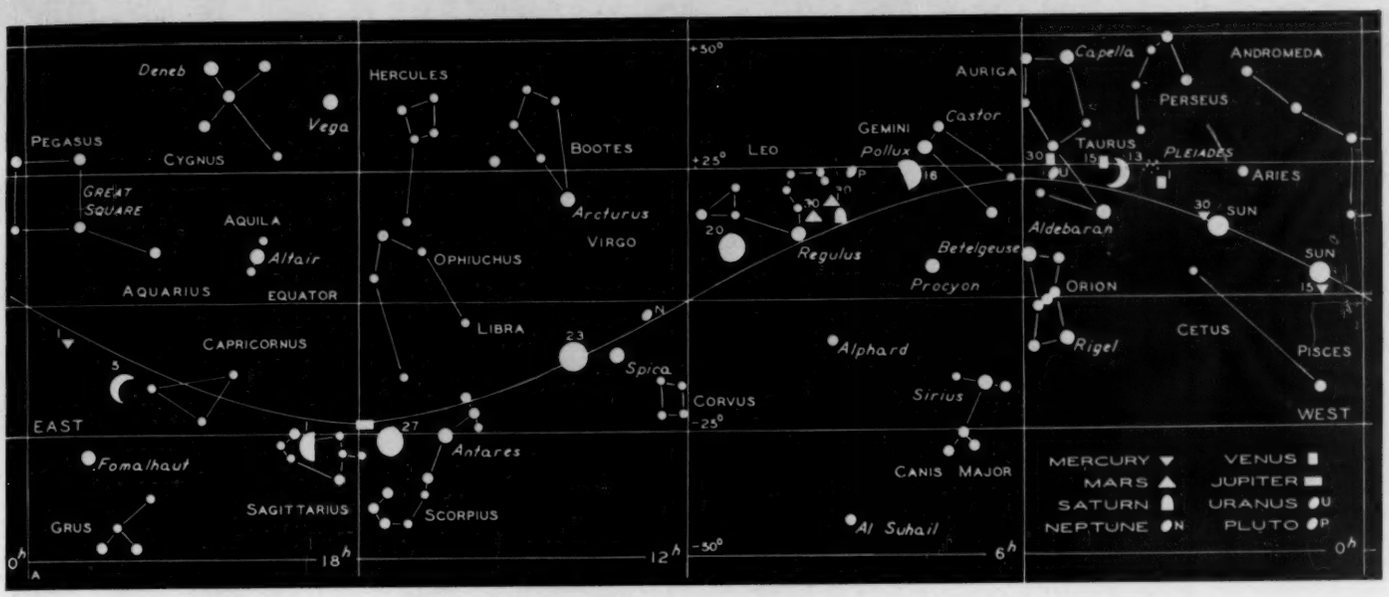
COMET BESTER

Predicted positions for Comet Bester, 1947k, for April and May are given here, as well as the magnitudes predicted on the fourth-power and sixth-power laws, respectively.

April 7, $18^h\ 50^m.5$, $+50°\ 26'$, 5.5, 4.0; April 15, $17^h\ 14^m.5$, $+67°\ 28'$, 6.1, 4.8; April 23, $14^h\ 07^m.6$, $+73°\ 08'$, 6.8, 5.7; May 1, $11^h\ 56^m.6$, $+68°\ 40'$, 7.5, 6.6; May 9, $11^h\ 04^m.4$, $+62°\ 46'$, 8.2, 7.4; May 17, $10^h\ 42^m.3$, $+57°\ 46'$, 8.8, 8.2; May 25, $10^h\ 32^m.4$, $+53°\ 46'$, 9.4, 8.9.

The first news of observations since perihelion passage comes from Roberto Ortiz Planos and Roberto Ortiz Hector, of Havana, Cuba, who wrote reporting the comet visible on March 6th, at 5 a.m., EST, less than half way from Theta Aquilae to Alpha 2 Capricorni. The object showed a well-defined nucleus and slight indications of a dim tail nearly perpendicular to the horizon. The magnitude was about 5th.

Observations at the Oak Ridge station of Harvard College Observatory confirm this magnitude, indicating from the ephemeris published in **Sky and Telescope**, December, 1947, that the comet's brightness is following the fourth-power law. Comet Bester 1947k probably will not become a spectacular object under present expectations, but will be interesting in field glasses and telescopes. See page 117 of the March issue for a chart of its predicted path until the end of May.



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

Mercury, a morning star, is too close to the sun to be observed.

Venus attains greatest elongation on April 25th, 45° 46′ east of the sun. At this time the planet will be 50 per cent illuminated and 23 seconds of arc in diameter. During April, Venus traverses Taurus, increases in brightness from −3.9 to −4.1, and sets four hours after the sun. On the 3rd, the planet will be about 1½° south of Alcyone, in the Pleiades, and on April 29th, it will pass 3° 45′ north of Uranus between Beta and Zeta Tauri.

Moon. A partial eclipse of the moon will occur on April 23rd, not visible from the Western Hemisphere except the extreme western and northwestern parts of North America. The obscured portion will be three per cent at maximum.

Mars resumed eastward motion on March 30th, toward Regulus once more. Near the end of the month it will be half way between Saturn and Regulus. The planets are of equal brightness, magnitude +0.5.

Jupiter rises at midnight; it has brightened to magnitude −1.9. The planet is located in western Sagittarius, 1° west of M20, the Trifid nebula. On the 15th, retrograde motion commences.

Saturn is almost stationary the entire month, 13° west of Regulus. It reaches the meridian shortly after sunset. In a telescope, the rings appear inclined 16° to the ecliptic.

Uranus is near Zeta Tauri.

Neptune arrives at opposition on April 1st, at 12h 45m.3, −3° 8′. The planet is between Gamma and Theta Virginis, closer to Gamma; its magnitude is +7.7. E. O.

METEORS IN APRIL

The Lyrids, a sparse annual shower, may be observed from April 20th to 22nd. A gibbous moon in Virgo will hinder observations. Rates of seven to 10 per hour are predicted for perfect conditions. The Lyrid meteors radiate from a point near Vega and are usually swift. E. O.

VARIABLE STAR MAXIMA

April 2, T Aquarii, 7.9, 204**405**; 5, X Monocerotis, 7.6, 065**208**; 8, T Cephei, 5.8, 210868; 13, T Columbae, 7.6, 051**533**; 13, R Leonis, 5.9, 094211; 16, R Aurigae, 7.8, 050953; 16, R Lyncis, 7.9, 065355; 21, R Octantis, 7.9, 055**686**; 23, T Centauri, 6.1, 133**633**; 28, R Trianguli, 6.3, 023133; 28, R Bootis, 7.3, 143227.

These predictions of variable star maxima are made by Leon Campbell, recorder of the AAVSO, Harvard College Observatory, Cambridge 38, Mass. Serious-minded observers interested in making regular telescopic observations of variable stars may write to Mr. Campbell for further information.

Only stars are included here whose mean maximum magnitudes, as recently deduced from a discussion of nearly 400 long-period variables, are brighter than magnitude 8.0 Some of these stars, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the predicted magnitude, and the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern).

PHASES OF THE MOON

Last quarter	April	1, 10:25
New moon	April	9, 13:16
First quarter	April	16, 19:42
Full moon	April	23, 13:28
Last quarter	May	1, 4:48

MINIMA OF ALGOL

April 2, 10:22; 5, 7:12; 8, 4:01; 11, 0:50; 13, 21:39; 16, 18:28; 19, 15:17; 22, 12:06; 25, 8:56; 28, 5:45. May 1, 2:34; 3, 23:23.

GREENWICH CIVIL TIME (GCT)

TIMES used on the Observer's Page are Greenwich civil or universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the GCT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown.

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OCCULTATION PREDICTIONS

April 15-16 **47 Geminorum** 5.6, 7:08.2 +26-56.6, 6, Im: **A** 0:03.8 −1.9 +0.1 71; **C** 23:55.9 −2.0 −0.5 88; **E** 23:27.1 −2.0 −0.1 93; **F** 23:20.8 −2.5 −2.1 132.

15-16 **134 B Geminorum** 6.5, 7:13.8 +26-47.1, 6, Im: **C** 2:56.9 −1.6 +0.2 53; **D** 2:55.6 ... ... 39; **E** 2:35.5 −1.6 −0.5 76; **F** 2:36.5 −1.3 −1.7 116; **H** 1:48.6 −2.0 −1.5 119.

16-17 **Lambda Cancri** 5.9, 8:17.4 +24-11.3, 7, Im: **A** 3:37.7 −0.1 −2.2 137; **B** 3:31.0 −0.2 −2.1 132; **C** 3:46.2 +0.2 −2.6 154; **D** 3:34.2 −0.1 −2.5 145.

17-18 **90 H¹ Cancri** 6.1, 9:10.7 +21-29.9, 8, Im: **A** 23:21.6 −1.8 −0.1 103; **C** 23:14.6 −1.8 −0.7 118; **E** 22:51.4 −1.5 −0.2 119.

18-19 **42 Leonis** 6.1, 10:19.0 +15-14.3, 9, Im: **A** 5:41.2 −1.1 −0.9 68; **B** 5:37.3 −1.2 −0.8 63; **C** 5:39.9 −1.0 −1.1 83; **D** 5:32.4 −1.2 −1.1 78; **E** 5:23.1 −1.2 −1.4 104; **F** 5:32.8 −0.9 −2.1 137; **G** 4:39.6 −1.3 −1.1 117; **H** 5:01.4 −0.5 −3.1 168; **I** 4:30.1 −1.2 −1.2 132.

For selected occultations visible at standard stations in the United States and Canada under fairly favorable conditions, these predictions give: evening-morning date, star name, magnitude, right ascension in hours and minutes and declination in degrees and minutes, moon's age in days, immersion or emersion; standard station designation, GCT, **a** and **b** quantities in minutes, position angle; the same data for each standard station westward.

Longitudes and latitudes of standard stations are:

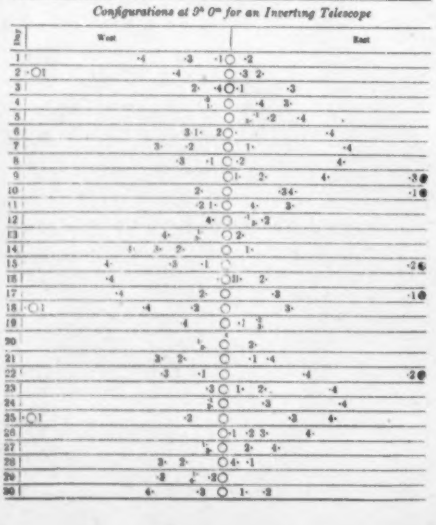
A	+72°.5, +42°.5	**E**	+91°.0, +40°.0
B	+73°.6, +45°.6	**F**	+98°.0, +30°.0
C	+77°.1, +38°.9	**G**	+114°.0, +50°.9
D	+79°.4, +43°.7	**H**	+120°.0, +36°.0
		I	+123°.1, +49°.5

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude respectively, enabling computation of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo** — **LoS**), and multiply **b** by the difference in latitude (**L** — **LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Greenwich civil time to your own standard time.

JUPITER'S SATELLITES

Jupiter's four bright moons have the positions shown below for the GCT given. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. Reproduced from the **American Ephemeris and Nautical Almanac.**

Configurations at 5h 0m for an Inverting Telescope



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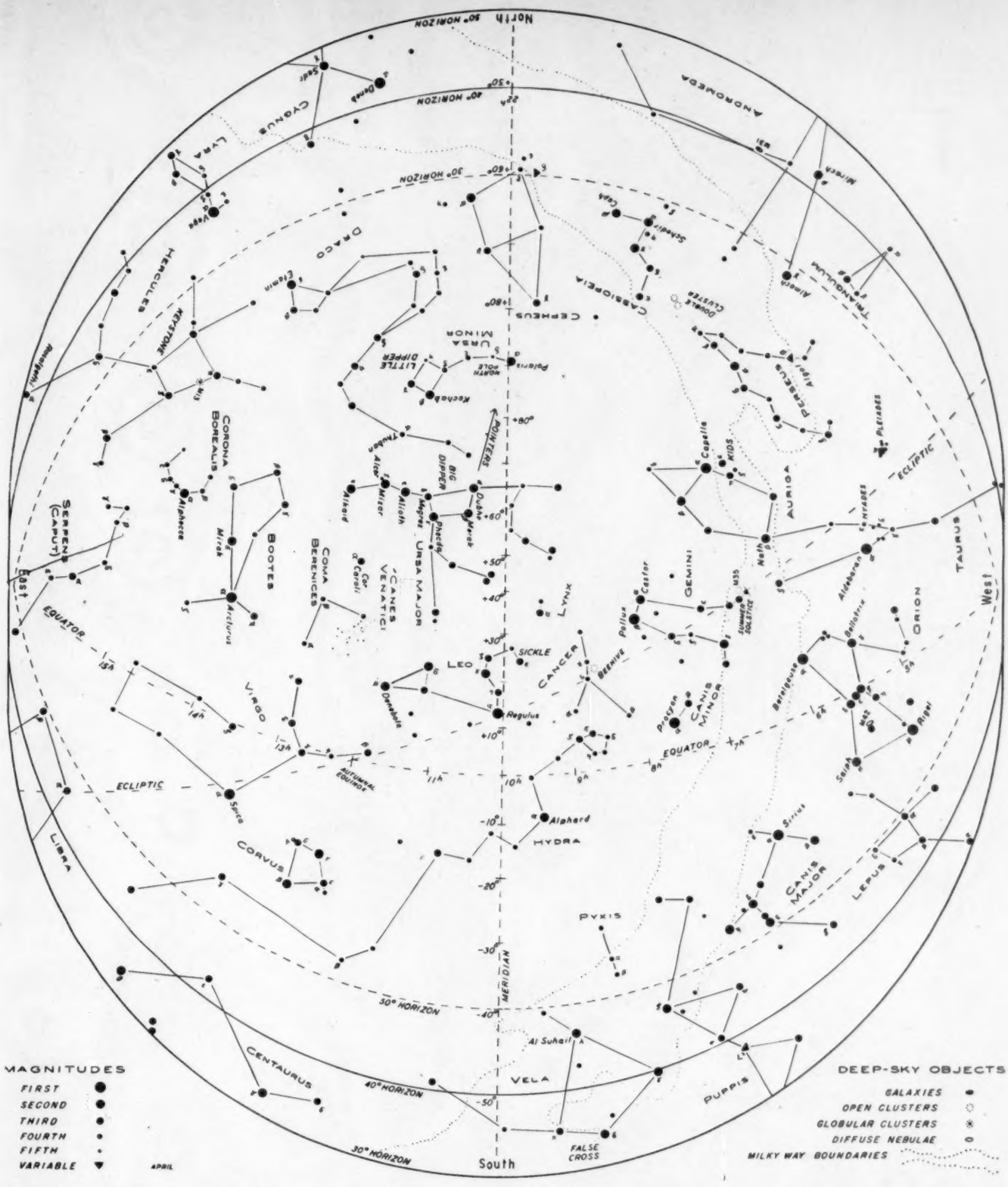

DEEP-SKY WONDERS

IN THE EASTERN REGION of Leo lie many faint clusters heralding the profusion in Coma. **M65** and **M66**, NGC 3623 and 3627, $11^h\ 16^m$, $+13°\ 23'$, are two faint spirals obviously elongated in different directions. **NGC 3810**, 21^1, $11^h\ 38^m$, $+11°\ 45'$, is magnitude 11.8, 4′ diameter, class Sc.

NGC 3599, 49^2 and **NGC 3607**, 50^2, a pair of galaxies at $11^h\ 14^m$, $+18°\ 19'$; Herschel called this triple with 51^2 (NGC 3608), but Smyth could see only two. Norton plots 49^2 and 50^2. Webb remarks that 49^2 may be variable. These are difficult objects in small telescopes, with magnitudes around 11.4 to 12.5, but this is an interesting group to test your telescope and atmosphere.

Try also **NGC 3655**, 5^1, $11^h\ 20^m$, $+16°\ 51'$, small and faint, 12.5 magnitude, 1′ by 0.5′; **NGC 3593**, 29^1, $11^h\ 12^m$, $+13°\ 6'$, a narrow spiral, extremely faint, 4′ by 1′.

WALTER SCOTT HOUSTON

STARS FOR APRIL

from latitudes 30° to 50° north, at 9 p.m. and 8 p.m. local time, on the 7th and 23rd of the month, respectively. The 40° north horizon is a solid circle; the others are circles, too, but dashed in part. For the year 1948, these simplified charts replace our usual white-on-black maps, which may be consulted in issues of prior years when information on deep-sky wonders and less conspicuous constellations is desired.